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Draft
Supplemental Environmental Impact Statement
Golden Sunlight Mine Pit Reclamation

December 2004

Montana Department of Environmental Quality
and
U.S. Bureau of Land Management

Mission Statement

The Bureau of Land Management is responsible for the stewardship of our public lands. It is committed to manage, protect, and improve these lands in a manner to serve the needs of the American people for all times. Management is based upon the principles of multiple use and sustained yield of our nation's resources within a framework of environmental responsibility and scientific technology. These resources include recreation; rangelands; timber; minerals; watershed; fish and wildlife; wilderness; air; and scenic, scientific, and cultural values.

The Department of Environmental Quality's mission is to protect, sustain, and improve a clean and healthful environment to benefit present and future generations.

Dedication

Laura Kuzel, DEQ Geochemist, passed away during the preparation of this SEIS. Laura was a dedicated scientist, always searching for more information. She wanted to make a difference. She was in her element when she was holding a rock hammer and collecting rock samples for analysis. This document is dedicated to her.

Cover Photos

The top two photographs were taken in June 2000 and July 2003 showing the view of the East Waste Rock Dump Offload Area during mining and after reclamation. The center photo is an aerial view of the pit taken by Tom Weitz in August 2004. The lower two photographs on the front cover were taken in May 2000 and June 2003 showing the view of the West Waste Rock Dump during mining and after reclamation. Photos are courtesy of GSM and Spectrum Engineering.

United States Department of the Interior
Bureau of Land Management
Butte Field Office

State of Montana
Department of Environmental Quality

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Pit Reclamation Alternatives

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Department of Environmental Quality
PO Box 200901
Helena, MT 59620

U.S. Department of the Interior
Bureau of Land Management
Butte Field Office
106 North Parkmont
Butte, MT 59701

December 2004

Dear Reader:

Enclosed for your review and comment is the Draft Supplemental Environmental Impact Statement (SEIS) for the Golden Sunlight Mine Pit Reclamation Alternatives.

To comply with the June 27, 2002, judgment of the Montana First Judicial District Court, the Montana Metal Mine Reclamation Act, and other applicable state and federal laws, rules, and regulations, the Montana Department of Environmental Quality (DEQ) and the U.S. Bureau of Land Management (BLM) have prepared this SEIS to evaluate pit reclamation alternatives at the Golden Sunlight Mine (GSM) for DEQ Operating Permit No. 00065 and BLM Plan of Operations #MTM82855. Under the Proposed Action, GSM would partially backfill the open pit and install wells in the backfill material to collect groundwater. The Draft SEIS analyzes the potential impacts of the proposed action as well as the potential impacts of alternatives: 1) No Pit Pond (no action); 2) Partial Pit Backfill With Downgradient Collection; and 3) Underground Sump. The Draft SEIS addresses issues and concerns raised during the public scoping period of May 7, 2003, to July 31, 2003, and during the public scoping meeting held in Whitehall on July 16, 2003. The operating permit is available for review at the DEQ office in Helena and at the BLM office in Butte.

DEQ and BLM have selected the Underground Sump Alternative with visual mitigations as the preliminary preferred alternative. **This is not a final decision.** The preferred alternative could change in response to public comment on the Draft SEIS, new information, or new analysis that might be needed in preparing the Final SEIS.

Public comments concerning the adequacy and accuracy of the Draft SEIS will be accepted for 60 days, until February 14, 2005. Written comments may be sent to the Montana Department of Environmental Quality, Director's Office, PO Box 200901, Helena, MT 59620-0901, attn: Greg Hallsten.

A public hearing to receive verbal and written comments will be held during the 60-day comment period. Hearing details will be announced through area media. Individuals and groups currently on the mailing list will be notified by mail.

The Final SEIS might only contain public comments and responses, and changes to the Draft SEIS. Please keep this Draft SEIS for future reference.

Tom Livers

for Jan P. Sensibaugh, Director
State of Montana
Department of Environmental Quality

Richard M. Hotaling, Field Manager
Bureau of Land Management
Butte Field Office

Draft Supplemental
Environmental Impact Statement

Golden Sunlight Mine
Pit Reclamation Alternatives
Jefferson County, Montana

December 2004

Lead Agencies: United States Department of the Interior, Bureau of Land Management, Headwaters Resource Area and State of Montana, Department of Environmental Quality, Environmental Management Bureau.

Cooperating Agencies: None.

Participating Agencies/Governments: United States Environmental Protection Agency.

Contact for Further Information: R. David Williams, Bureau of Land Management, Butte Field Office, 106 North Parkmont, Butte, MT 59701 (406/533-7655) and Greg Hallsten, Montana Department of Environmental Quality, P.O. Box 200901, Helena, MT 59620-0901 (406/444-3276).

Abstract: This SEIS is a draft supplement to the April 1998 Final EIS, *Environmental Impact Statement Amending and Adopting the Draft Environmental Impact Statement - Golden Sunlight Mine*.

Comments: Comments should be received by close of business on February 14, 2005, and addressed to: Greg Hallsten, Director's Office, Montana Department of Environmental Quality, P.O. Box 200901, Helena, MT 59620-0901. Comments may also be sent electronically to: Greg Hallsten at *ghallsten@state.mt.us*

Draft Supplemental
Environmental Impact Statement

Golden Sunlight Mine
Pit Reclamation Alternatives
Jefferson County, Montana

December 2004

Lead Agencies: United States Department of the Interior, Bureau of Land Management, Headwaters Resource Area and State of Montana, Department of Environmental Quality, Environmental Management Bureau.

Cooperating Agencies: None

Participating Agencies/Governments: United States Environmental Protection Agency

Contact for Further Information: P. David Williams (Bureau of Land Management, Butte Field Office, 106 North Parkmont, Butte, MT 59701 (406/533-7600) and Greg Hallsten, Montana Department of Environmental Quality, P.O. Box 200901, Helena, MT 59620-0901 (406/444-3276).

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SUMMARY

PURPOSE AND NEED

Golden Sunlight Mines, Inc. (GSM) conducts open pit mining and mineral processing on private and public lands under Operating Permit No. 00065, issued by the Montana Department of Environmental Quality (DEQ) in 1972, and Plan of Operations #MTM82855, issued by the Bureau of Land Management (BLM) in 1982. A major mine expansion permitted in 1998 was challenged in District Court. The District Court ruled, based on the record before the court, that GSM's reclamation plan must include backfilling the pit. BLM notified DEQ that backfilling the pit may result in "unnecessary or undue degradation of public lands" and that BLM must prepare a supplemental review pursuant to the National Environmental Policy Act (NEPA) and approve the modification to the reclamation plan. On October 24, 2002, DEQ, acting pursuant to the June 27, 2002, District Court judgment, ordered GSM to submit a modified partial pit backfill plan to meet the requirements of the Metal Mine Reclamation Act (MMRA), its implementing rules, and the judgment of the District Court. The plan was to take into consideration current conditions at the mine site and address compliance with the Montana Water Quality Act. GSM submitted a proposed partial pit backfill plan on December 2, 2002. This Supplemental Environmental Impact Statement (SEIS) evaluates the potential impacts of the backfill plan and alternatives pursuant to NEPA and the Montana Environmental Policy Act (MEPA).

ISSUES

A Notice of Intent (NOI) to prepare the SEIS was published in the Federal Register on May 7, 2003. The NOI invited scoping comments to be sent to DEQ and BLM through June 7, 2003. On July 1, 2003, a news release was issued to area newspapers, State of Montana Newslinks Service, and major interest groups. A public scoping meeting was held near the mine in Whitehall, Montana, on July 16, 2003. DEQ and BLM also used the Multiple Accounts Analysis (MAA) process to help develop and evaluate alternatives.

Technical Issues

Technical issues include the design and constructibility of the alternatives that were evaluated, pit highwall stability and maintenance, backfill maintenance, the effects of subsidence in the underground workings, operational and maintenance requirements of the groundwater/effluent management system, storm water management maintenance requirements, soil cover maintenance requirements, water treatment plant operating and sludge management requirements, and the flexibility of the alternative for implementing new technologies in the future.

Environmental Issues

Environmental issues include impacts to groundwater quality and quantity, the risk of violation of groundwater quality standards and impairment of beneficial uses of the Jefferson River alluvial aquifer, impacts to surface water quality and quantity, the risk of violation of surface water quality standards and impairment of beneficial uses of the Jefferson River and Slough, surface disturbance, hazards to wildlife, and the amount of disturbed land left unrevegetated.

Socioeconomic Issues

Socioeconomic issues include worker and public safety, mining and reclamation employment, tax revenue, access to future mineral reserves and resources, land use after mining, aesthetics, and the future burdens on society and GSM.

Project Economics Issues

Project economics issues include the costs of reclamation.

ALTERNATIVES ANALYZED IN DETAIL

No Pit Pond Alternative (No Action)

Under the No Pit Pond Alternative, the bottom 100 feet of the pit would be backfilled with crusher reject waste rock to create a backfill sump. The backfill would serve as a flat working surface on which to station two to three dewatering wells and other components of a collection system. The dewatering system would collect water in the sump and pump it to a permanent water treatment plant. By maintaining the groundwater level as low as possible in the backfill, no water would be allowed to pond in the pit bottom. Protection for the pumping facilities and workers would be provided by building one or more berms around the perimeter of the 1.3-acre working area to trap rocks that might fall from the pit highwall. A 3-foot soil cover system would be placed over the backfill.

Partial Pit Backfill With In-Pit Collection Alternative (Proposed Action)

Under this alternative, the pit would be backfilled with waste rock from the East Waste Rock Dump Complex to create a free-draining surface. The upper pit highwall would be cast blasted and contoured to 2H:1V slopes. A 3-foot soil cover system would be placed over the graded area and revegetated. Four dewatering wells would be installed through the backfill to bedrock to maintain the pit as a hydrologic sink, and the water would be pumped to a permanent water treatment plant.

Partial Pit Backfill With Downgradient Collection Alternative

This alternative is a variation of the Partial Pit Backfill With In-Pit Collection Alternative. The pit would be backfilled, and the pit highwall would be reduced, as in the Partial Pit Backfill With In-Pit Collection Alternative. The pit would not be maintained as a hydrologic sink by installing wells inside the backfilled area. Instead, a system of wells would be operated outside of and down gradient from the pit to intercept contaminated groundwater after it has left the pit. The system would include an estimated 26 or more new capture wells, existing wells in the Tailings Impoundment No. 1 capture system, and 10 new monitoring wells.

Underground Sump Alternative

The Underground Sump Alternative is similar to the No Pit Pond Alternative, except no backfill would be placed in the pit, and the underground workings would be improved and maintained as a sump for pit dewatering.

ALTERNATIVES CONSIDERED BUT DISMISSED

Partial Pit Backfill Without Collection

The Partial Pit Backfill Without Collection Alternative was developed to evaluate the possibility of avoiding long-term pit water collection and treatment. Reclamation would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative and the Partial Pit Backfill With Downgradient Collection Alternative; however, wells would not be installed. Natural attenuation and mixing of contaminated pit groundwater with ambient groundwater would be relied on to meet groundwater quality standards at the mixing zone boundary. This alternative was dismissed because compliance with groundwater quality standards could not be guaranteed without downgradient or in-pit collection of contaminated groundwater.

Partial Pit Backfill With Amendment Alternative

The Partial Pit Backfill With Amendment Alternative was developed to try to avoid the need for long-term pit water collection and treatment. Reclamation would be the same as under the Partial Pit Backfill With In-Pit Collection and Partial Pit Backfill With Downgradient Collection alternatives, except lime would be added to the waste rock to increase the pH of the water in the backfill. This alternative was dismissed because analysis indicated that without downgradient groundwater capture, compliance with groundwater quality standards for certain constituents could not be guaranteed.

Pit Pond Alternative

The possibility of creating a pit pond with biologic mitigation was analyzed. The objective would be to design a pond that could sustain aquatic life and provide beneficial uses once it was developed. In the Pit Pond Alternative, the pit would be allowed to fill with precipitation, groundwater, and runon water. The water would be treated in the pit with microbes, nutrients, etc. This alternative would have no clear advantage over the Underground Sump Alternative. Without further technical review, any pond concept could only be considered by the agencies on a trial basis. Consequently, this alternative was dismissed.

SUMMARY OF IMPACTS

Table 1 summarizes and compares the impacts of each alternative considered.

PREFERRED ALTERNATIVE

The rules and regulations implementing MEPA and NEPA (ARM 17.4.617 and 40 CFR 1502.14, respectively) require that the agencies indicate a preferred alternative, if one has been identified. Stating a preference at this time is not a final decision. The preferred alternative could change in response to public comment on the Draft SEIS, new information that becomes available, or new analysis that might be needed in preparing the Final SEIS. The preferred alternative at this time is the Underground Sump Alternative with visual mitigations described in Section 4.8.3.2 of the Draft SEIS.

Rationale for Selection

Under all alternatives, no highwall failure that would be a threat to public safety or the environment would occur and some wildlife habitat would be provided. However, only the Underground Sump and No Pit Pond Alternatives provide adequate assurance that pollution of the Jefferson River in violation of water quality laws will not occur. These alternatives would provide complete control of pit seepage through evaporation and collection. This would eliminate the possibility of contaminated water passing the mixing zone boundary and reaching the Jefferson River alluvial aquifer, thus violating the Water Quality Act. Complete control of pit seepage cannot be guaranteed under the other alternatives because of the problems associated with drilling and operating wells in the 875 feet of reactive backfill and with effectively capturing seepage in or down gradient of the pit.

With the imposition of the visual mitigations described in Section 4.8.3.2 of the Draft SEIS, the Underground Sump and No Pit Pond Alternatives also mitigate post reclamation visual contrasts between the pit and adjacent lands.

The Underground Sump Alternative would pose less risk to workers monitoring and operating the water capture system from rock raveling from the highwall than would the No Pit Pond Alternative. Under the No Pit Pond Alternative, the workers would perform these functions while exposed to the highwall. Under the Underground Sump Alternative, much of the work would be performed underground. In addition, the Underground Sump Alternative would require less maintenance than the No Pit Pond Alternative because it would not be susceptible to damage from rock raveling from the highwall.

The Bureau of Land Management is mandated by the Federal Land Policy and Management Act (PL 94-579) and subsequent 43 CFR 3809 surface management regulations to manage federal lands so as to avoid unnecessary or undue degradation of the federal lands. The preferred alternative avoids unnecessary or undue degradation of the land by maximizing the amount of mine impacted water collected and treated, limiting the potential for mine impacted water to escape collection, and limiting the potential for water quality violations at the mine's permit boundary.

Table 1 Summary Comparison of Impacts Under the Proposed Action and Alternatives

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Technical Issues				
Design & constructability of the alternative				
Proven design	Backfilling with 111,000 cubic yards of acidic waste rock this volume of material to a depth of 100 feet is a proven design. Dewatering this volume of material to a depth of 100 feet is a proven design.	Backfilling with 33 million cubic yards of acidic waste rock and cast blasting and dozing the highwall to a 2H:1V slope is technically feasible. Dewatering waste rock backfill from a depth of up to 875 feet has not been proven.	Similar as Partial Pit Backfill With In-Pit Collection Alternative. Pumping out of downgradient drainages in natural geologic formations up to 200 feet deep is done regularly, but overall 95 percent capture may not be achievable.	Not applicable. Maintaining hydrologic connection between the pit bottom and an underground sump 25 to 75 feet below the pit and pumping from the sump have been done successfully at GSM and other mines.
Design & constructability of the alternative				
Ability to construct the alternative at GSM	Problems with constructing this alternative would be minimal.	There would be more problems developing and implementing this alternative than the No Pit Pond Alternative because of the larger volume and depth of backfill needed, the amount of cast blasted material, and the problems drilling dewatering wells in up to 875	There would be more problems developing and implementing this alternative than the No Pit Pond Alternative because of the larger volume and depth of backfill needed and the amount of cast blasted material. Installing dewatering wells in downgradient drainages in natural geologic formations up	GSM has developed and maintained an underground mine, including an underground sump connected to the open pit.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
		feet of unconsolidated waste rock in order to maintain the pit as a hydrologic sink.	to 200 feet deep has been done successfully at GSM.	
Pit highwall				
Pit highwall stability	Some portions of the pit highwall would be subject to raveling, talus formation, erosion, and limited sloughing. The overall stability of the pit highwall would be expected to increase over the long term as the rock materials achieve a more stable configuration.	No pit highwall would remain exposed. Backfilling the pit would eliminate pit highwall raveling and sloughing. Cast blasting would enhance the inherent stability of the pit highwall by reducing the slope to 2H:1V. The long-term stability of the pit highwall would be greater than the No Pit Pond Alternative.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative.
Pit highwall maintenance requirements	Raveling and sloughing of the highwall would require periodic maintenance to re-establish the 5,700-foot-elevation safety bench, clear the access road, haul more backfill to create a new working surface in the pit bottom, and move rock to re-establish safety berms. This could occur more than once over the long term.	No highwall maintenance would be needed.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative. Depending on the location of highwall raveling and sloughing, access to the 4,550-foot portal and the underground dewatering system could be lost. The 5,700-foot safety bench and access to the 4,550-foot portal would have to be re-established.
Backfill				
Backfill maintenance requirements	Settling in 100 feet of backfill would be limited to 10 feet. Repairs would be needed to bring the backfill back to grade.	Up to 150 feet of settling could occur in the 875 feet of backfill, with 60-75% of the settling occurring during the backfilling operation. Repairs would be needed to bring the backfill back to grade.	Up to 200 feet of settling could occur in the 875 feet of backfill after it is inundated with groundwater. Most settling would occur during the backfilling operation, with the remaining settling occurring	Not applicable.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
		Settling in the backfill would affect storm water diversions on the 2H:1V slopes.	with inundation over about 100 years. Repairs would be needed to bring the backfill back to grade. Settling in the backfill would affect storm water diversions on the 2H:1V slopes.	
	Raveling and sloughing of the highwall would require periodic maintenance to re-establish the working surface and drill new wells.	The highwall would not ravel or slough.	The highwall would not ravel or slough.	Not applicable.
Underground workings				
Impacts to pit facilities due to subsidence related to underground mining	While subsidence of the underground workings is not expected, localized failures of the walls and ceiling over time could result in subsidence, especially in seep and fault areas where chemical weathering would be increased. Subsidence could cause settling in the 100 feet of backfill, affecting the dewatering wells in the backfill.	Same as the No Pit Pond Alternative. Subsidence could cause settling in up to 875 feet of backfill, affecting the dewatering wells in the backfill.	Similar to the Partial Pit Backfill With In-Pit Collection Alternative except the dewatering wells down gradient of the pit would not be affected.	Same as the No Pit Pond Alternative except localized failures of ceiling and walls in seep and fault areas could occur over time affecting access to the dewatering system in the underground workings.
Groundwater/ effluent management system				
Operation requirements (number of wells)	Two to three wells would be constructed through the pit backfill about 100 feet deep to the bedrock contact.	Four wells would be constructed through the pit backfill up to 875 feet deep to the bedrock contact. Wells would need to be replaced regularly.	The agencies have assumed that an additional 26 capture wells and 10 monitoring wells would be constructed down gradient from the pit. This number of wells may not be	No wells would be constructed. Drill holes would be used to direct pit water to the underground sump.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
			enough to ensure compliance with groundwater quality standards at the mixing zone boundary.	
Maintenance of capture points	Settlement of the 100 feet of backfill could cause separation, buckling, or shearing of well casings. About 70 percent of settlement would occur during the backfill operation and 30 percent over a longer period after backfilling is complete.	Settlement effects on well casings would be more severe than under the No Pit Pond Alternative.	Wells would be constructed outside of the pit and would not be subject to backfill settling.	There would be no backfill to settle and no wells to damage. Rock fall from ceiling and walls of the underground workings could damage the dewatering system.
	Corrosion of the well casings, pumps, electrical components, monitoring equipment and pipelines from the acidic water in the backfill would cause periodic need for repair and replacement of dewatering system components.	Same as the No Pit Pond Alternative.	Short-term buffering by the aquifer and mixing with ambient groundwater would limit corrosion of pumps and screens, providing for longer pump life. After the buffering capacity of the aquifer is used up in a few tens of years, water quality would be similar to the No Pit Pond and Partial Pit Backfill With In-Pit Collection alternatives.	Corrosion would be similar to the No Pit Pond Alternative.
	Highwall raveling and sloughing could damage wellheads, monitoring equipment, power lines, and pipelines.	Not applicable.	Not applicable.	Similar to the No Pit Pond Alternative.
	Pumping rates and lifts would not be a problem.	Lower pumping rates and higher lifts compared to the No Pit Pond Alternative	Similar to the No Pit Pond Alternative.	Similar to the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
		would cause more pump failure and may cause the need to allow the water table to rebound for pumping efficiency.		
	Not applicable.	Not applicable.	Not applicable.	Access to the underground would be needed. The agencies have assumed sloughing could bury the 4,550-foot elevation portal blocking access to the dewatering system needed for maintenance.
Storm water runon/runoff management				
Maintenance requirements (drainage channels off 2H:1V slopes)	Diversions would route water away from the pit. Settling of diversions constructed on unconsolidated materials and accumulations of sediment and material sloughed from above would impair diversions' function. Periodic cleaning and repairs would be needed. Eventually portions of the diversions would need to be reconstructed completely.	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.
	Not applicable.	Diversions would be constructed on the 2H:1V slopes created by highwall reduction. Settling in the	Maintenance requirements would be similar to the Partial Pit Backfill With In-Pit Collection Alternative. More	Not applicable.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
		backfill could cause depressions where surface water could accumulate, infiltrate, and saturate the soil cover resulting in erosion on the face of the reclaimed slopes. Maintenance requirements for diversions would be the same as for the No Pit Pond Alternative, except there would be more diversions to maintain.	settlement would occur due to saturation of the backfill.	
Soil cover				
Soil cover maintenance requirements (erosion, revegetation)	A 3-foot soil cover would be placed and revegetated on the pit floor, pit benches, and roads, totaling 53 acres.	A 3-foot soil cover would be placed and revegetated on the backfilled pit and reduced highwall, totaling 274 acres.	Similar to the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative except there would be 1.3 fewer acres to maintain in the pit.
	Eroded areas would need to be repaired, resoiled, and reseeded. Noxious weeds would have to be controlled.	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.
	The backfill surface would need to be regraded as the backfill settles. Rocks that ravel or slough from the highwall onto revegetated areas would need to be cleared. Depending on the volume of rock, regrading, resoiling, and reseeding of reclaimed surfaces may be needed.	Backfill would settle up to 150 feet. More backfill would have to be placed, graded, resoiled, and revegetated.	Backfill would settle up to 200 feet.	There would be no backfill needing cover maintenance.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	Highwall seeps could saturate the soil cover with acidic water, contaminating soils and impairing revegetation success. The seep would have to be located and dewatered, contaminated soil would have to be replaced with clean soil, and the area would have to be revegetated.	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.
Water treatment				
Additional sludge management requirements	32 gpm of pit water would need treatment. The sludge management requirements would be similar to or less than estimated in the 1997 Draft EIS.	15 gpm of pit water would need treatment. Weathering would continue to produce oxidation byproducts in the unsaturated backfill. Pumping would limit saturation of the backfill and impacts from jarosite dissolution. More sludge would be produced per gallon of treated water than under the No Pit Pond Alternative, but less water would be treated, so the sludge management requirements would be similar or less.	A maximum of 121 gpm of groundwater would be collected and treated trying to capture 95 percent of the 16 gpm of pit discharge. Weathering would continue to produce oxidation byproducts in the unsaturated backfill. Jarosite in the saturated portion of the backfill would prevent reducing conditions from developing and allow further production of acid. Metals would be released during the dissolution of jarosite. The flow from the unsaturated portion of the backfill above the water table would contribute low pH water with high metals concentrations to the pit discharge for hundreds of years. There is limited natural attenuation capacity along the	Same as No Pit Pond Alternative. The agencies have assumed that the water produced in the underground workings would be comparable to the water quality in the No Pit Pond Alternative. Because there would be no backfill, jarosite, adsorbed metals, and other oxidation byproducts would remain relatively immobile in the waste rock dump complex. There would be minimal additional sludge.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
			primary and secondary flow paths from the pit. The sludge management requirements would be about the same as the Partial Pit Backfill With In-Pit Collection Alternative because the chemical mass would be about the same.	
Additional operating requirements	There would be no additional water treatment operating requirements. The water treatment system in the SEIS is the same as that evaluated in the 1997 Draft EIS, and there would be less pit water to treat.	Same as the No Pit Pond Alternative.	The water treatment plant could require additional operating cost due to the increased water quantity treated under this alternative.	Same as the No Pit Pond Alternative.
Flexibility for future improvements				
Potential for utilization of new technologies	New technology, such as in situ water treatment, would be easier to apply in the less than 600,000 cubic yards of pit backfill and raveled and sloughed highwall rock under the No Pit Pond Alternative than it would be in the larger volumes of backfill under the partial pit backfill alternatives.	New technology, such as in situ water treatment, would be harder to apply in 47 million cubic yards of pit backfill than under the No Pit Pond Alternative. Because of the problems with maintaining wells in acidic waste rock in the deeper backfill, this alternative offers less potential for utilization of new technologies. It would be harder to redesign the dewatering system in up to 875 feet of backfill.	Similar to the Partial Pit Backfill With In-Pit Collection Alternative, except that in-situ water treatment would be more difficult because of the lack of wells in the backfill. If treatment were attempted outside of the pit, a dispersed plume may be more challenging to track, contain, and treat in-situ.	New technology, such as in situ water treatment, would be easier to apply in the open water of an underground sump than in backfill.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Environmental Issues				
Impacts to groundwater quality and quantity				
Risk of impacts to groundwater quality and quantity in permit area	The pit would be maintained as a hydrologic sink, and 32 gpm of pit water would be collected and treated before being discharged. Impacts to groundwater quality from pit outflows are expected to be minimal.	Same as the No Pit Pond Alternative, except 15 gpm would be collected and treated.	The pit would not be a hydrologic sink. Groundwater capture efficiency of 95 percent or greater of the 16 gpm of pit discharge would be required to meet water quality standards in the Jefferson River alluvial aquifer. This may not be achievable.	Same as the No Pit Pond Alternative, except 32 gpm would be pumped from the underground sump and treated.
	The groundwater level around the pit would be permanently drawn down. This would result in minor reductions in the flows of springs that are hydrologically connected to the pit.	Same as the No Pit Pond Alternative.	The groundwater level around the pit would rebound so that the flows of springs that are hydrologically connected to the pit could be increased. Because of the higher pit groundwater elevation, ARD water from the pit could move along secondary flow paths in the bedrock and Bozeman Group aquifers where it is more difficult to detect and collect. Groundwater quality would likely be degraded up gradient of the collection wells where groundwater is already impacted by ARD from natural mineralization and may eventually be impacted from a	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
			small portion of the East Waste Rock Dump Complex. The potential for creating new springs or affecting water quality of existing springs is higher than under the other alternatives.	
Risk of violation of groundwater standards at permit boundary and impacts to beneficial uses of the Jefferson River alluvial aquifer	Groundwater quality standards would be met at the permit boundary. Beneficial uses of the Jefferson River alluvial aquifer would not be affected.	Same as the No Pit Pond Alternative.	Groundwater quality standards would be met at the permit boundary with 95 percent or greater capture efficiency, and beneficial uses of the Jefferson River alluvial aquifer would not be affected. This may not be achievable. The current groundwater classification would be unchanged. With a lesser capture efficiency, groundwater quality standards for copper and nickel would be exceeded at the permit boundary and within the Jefferson River alluvial aquifer. DEQ would have to review the mixing zone.	Same as the No Pit Pond Alternative.
Impacts to surface water quality and quantity				
Impacts to springs, wetlands	The groundwater level around the pit would be permanently drawn down resulting in minor reductions in the flows of springs that are hydrologically connected to the pit.	Same as the No Pit Pond Alternative.	The groundwater level around the pit would rebound so that the flows of springs that are hydrologically connected to the pit would remain the same or increase. New springs or seeps could be created that would be impacted by ARD from the pit.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
			Discharges of ARD at existing springs around the pit area could increase.	
Risk of violation of surface water standards and impacts to beneficial uses of the Jefferson River and Slough	There would be no pit discharge. There would be no risk of violation of surface water standards and impacts to beneficial uses in the Jefferson River and Slough.	Same as the No Pit Pond Alternative.	The risk of contaminants reaching the Jefferson River or Slough and affecting surface water quality and beneficial uses is greater than for alternatives that maintain the pit as a hydrologic sink. Ninety-five percent groundwater capture efficiency would be needed to prevent exceeding groundwater quality standards after mixing with groundwater in the Jefferson River alluvial aquifer. High capture efficiencies may not be achievable. Control of pit seepage along secondary pathways may be difficult. There is little attenuation capacity in the Tertiary debris flow/colluvial aquifer.	Same as the No Pit Pond Alternative.
Reclamation plan changes				
Surface disturbance	No new pit disturbance.	56 acres of new pit disturbance.	Same as the Partial Pit Backfill With In-Pit Collection Alternative, except 2 additional acres would be disturbed for downgradient wells.	Same as the No Pit Pond Alternative.
Hazards to wildlife	There would be no additional hazards to wildlife.	There would be fewer hazards to wildlife than under the No Pit Pond Alternative because the highwall would be eliminated.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Total remaining unrevegetated acres	158 acres	0 acres	0 acres	159 acres
		Socioeconomic Issues		
Safety				
Risk to workers (reclamation and construction)	The safety risk to reclamation workers would be increased while backfill is being hauled down the steep roads into the pit because of the potential for truck accidents.	The safety risk to reclamation workers would be the same as under the No Pit Pond Alternative while 100 feet of crusher reject is being hauled down the steep roads into the pit. The rest of the backfilling would be by end dumping waste rock from the pit rim, a standard method used during mining that has less risk than hauling loaded trucks to the bottom of the pit. Cast blasting and dozing to reduce the pit highwall would present risks to workers.	Similar to the Partial Pit Backfill With In-Pit Collection except separate placement of crusher reject in the bottom of the pit would not be required.	Less than the No Pit Pond Alternative. Backfill would not be hauled into the pit.
	Workers would be below a highwall of up to 1,875 feet high with the risk of injury from rock falls.	Workers installing, operating, and maintaining the dewatering system would not be working below a highwall and would not be at risk of injury from rock falls.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Workers would be exposed to rock falls from the walls and ceiling of the underground workings as well as from the highwall. Overall risk would be less than the No Pit Pond Alternative.
Risk to workers (long-term maintenance)	Workers in the pit would be exposed to pit highwall raveling and sloughing. Long-term access would be needed to the pit bottom for monitoring and	Workers would not be exposed to pit highwall raveling and sloughing. Long-term access to the pit bottom would not be required. The risk to worker safety in this	Similar to the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative, except workers would be exposed to rock falls from the walls and ceiling of the underground workings as well as from the highwall.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	maintenance of the pit haul road, 5,700-foot-elevation pit safety bench, and the dewatering system.	alternative would be less than the No Pit Pond Alternative and would be similar to the risk of work currently conducted on the waste rock dump complexes.		Overall risk would be less than the No Pit Pond Alternative.
Risk to public safety	Access restrictions on general public use would be maintained and would consist of signs, berms, and fencing around the pit area, but there would still be a risk to public safety from the pit highwall.	Same as the No Pit Pond Alternative except and there would be no risk to public safety from the pit highwall.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.
Mining employment				
Potential employment from mining Stage 5B	750 person years	750 person years. Premature closure would reduce this by 150 person years per year.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.
Reclamation employment				
Reclamation employment opportunities	123 person years	308 person years	308 person years	124 person years
Revenue from taxes				
Potential tax revenues from mining Stage 5B	$8,087,000	Same as the No Pit Pond Alternative, except premature closure would reduce this to $60,000.	Same as the No Pit Pond Alternative, except premature closure would reduce this to $60,000.	$8,087,000
Potential tax revenues from pit backfill	$319,500	$806,000	$911,000	$322,000
Mineral reserves and resources				
Access to future mineral reserves/ resources	If the pit were to be enlarged for additional mining in the future, it	If the pit were to be enlarged for additional mining in the future, it would take 116	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	If the pit were to be enlarged for additional mining in the future, it would take 0.5 month

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	would take 1.5 months to remove the 600,000 cubic yards of backfill, soil, and highwall rock. Time is based on the 2002 mining rate of 405,000 cubic yards per month.	months to remove the 47 million cubic yards of backfill and soil, though it would likely take less than that. Time is based on the 2002 mining rate of 405,000 cubic yards per month.		to remove the 200,000 cubic yards of highwall rock and soil. Time is based on the 2002 mining rate of 405,000 cubic yards per month.
	The pit would have to be dewatered before it could be enlarged. The additional time required to dewater the pit would be minimal.	The pit would have to be dewatered. The additional time required to dewater the pit would be the same as the No Pit Pond Alternative.	Because the water table would rebound, more of the backfill would have to be dewatered as mining proceeded. The time required to dewater the pit would be longer than the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative.
Land use after mining				
Suitability of land use after mining	The land use after mining would be wildlife habitat. About 60 acres would be revegetated. About 158 acres of mule deer habitat would be lost. Limited raptor and bat habitat would be developed in the upper highwall.	The land use after mining would be wildlife habitat. About 272 acres would be revegetated. Up to 2 acres of habitat would be lost for access roads. Raptor and bat habitat would not be developed.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Aesthetics				
Visual contrast with adjacent lands	Portions of the highwalls and benches would remain visible. Overall visual contrasts would be reduced to a level where they are noticeable but not dominant in the landscape, following successful reclamation and revegetation. Landscape modifications would be consistent with the suggested VRM Class III rating for the area.	The reclaimed 2H:1V slopes covering the pit highwall and the reclaimed slopes of the waste rock dump complexes would still be visible, but the overall contrasts would be reduced under this alternative.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.
Potential future burden				
Potential future burden on society	The consequence of failure of this alternative would be creation of a pit pond below the 5,050-foot elevation. Minimal impacts to groundwater and springs would occur.	The consequence of failure of this alternative would be uncontrolled discharges of ARD-impacted groundwater from the backfilled pit, which could adversely impact springs and beneficial uses of the Jefferson River alluvial aquifer.	Same as Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.
Potential for future liabilities for GSM	No water would leave the pit. If the dewatering system failed, it could be re-established on the regraded pit bottom through 200 feet of backfill and sloughed highwall rock more easily than through up to 875 feet of backfill. Continued safe access to the dewatering system for operation and maintenance would be more difficult than	No water would leave the pit. If the dewatering system failed, it could be re-established by drilling new wells. Drilling and maintaining wells in up to 875 feet of backfill would be problematic. Safe access to the dewatering system for operation and maintenance would not be a problem because there would be no highwall.	The potential for water quality degradation outside of the pit would be increased. About 16 gpm of untreated water would escape the pit. If the dewatering system failed to capture 95 percent of the groundwater, groundwater standards for some constituents would be exceeded at the edge of the mixing zone.	No water would leave the pit. Removing water from the underground sump would be easier than pumping out of backfill. If the dewatering system failed, it could be re-established more easily than under the partial pit backfill alternatives. Continued safe access to the dewatering system for operation and maintenance because of wall and ceiling rock sloughing in

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	the partial pit backfill alternatives because of highwall rock raveling and sloughing onto safety benches and access roads.			the underground workings would be less risky than the No Pit Pond Alternative.
	Removing water from 100 feet of backfill would not be a problem. Dewatering system components would fail regularly from backfill settling and corrosion.	Removing water from up to 875 feet of backfill would be difficult. Dewatering system components would fail more often than under the No Pit Pond Alternative.	The agencies assume the quality of the water collected down gradient of the pit would be partially attenuated and mixed with regional groundwater, but 95 percent capture may not be achievable. Dewatering system components would not fail as regularly due to settling and corrosion.	Dewatering system components would not fail as regularly due to corrosion.
Project Economics Issues				
Costs				
Reclamation costs	$1,168,000	$55,355,000	$55,357,000	$1,260,000

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Chapter 1

Purpose and Need for Proposed Action

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Chapter 1

Purpose and Need for Proposed Action

1.1 INTRODUCTION

This document supplements the 1998 Final Environmental Impact Statement (EIS) prepared for a proposed expansion of mining operations at the Golden Sunlight Mine (GSM) (DEQ and BLM, 1998a). This Supplemental Environmental Impact Statement (SEIS) has been prepared to update site-specific information and evaluate reclamation alternatives for the GSM open pit after mining is completed. As required by the National Environmental Policy Act (NEPA) and the Montana Environmental Policy Act (MEPA), this SEIS identifies the Proposed Action, defines and evaluates alternatives to that action, and identifies potential environmental impacts of the Proposed Action and alternatives.

This SEIS follows the Council on Environmental Quality's (CEQ) recommended document organization (40 Code of Federal Regulations (CFR) 1502.10). Chapter 1 presents the purpose and need for Proposed Action. Chapter 2 describes and compares the Proposed Action and alternatives, and identifies the agencies' Preferred Alternative. Chapter 3 describes the affected environment. Chapter 4 presents the environmental consequences associated with the Proposed Action and alternatives, including direct, indirect, and cumulative impacts, and describes agency mitigations to reduce or minimize impacts. Chapter 5 presents information on consultation and coordination. Chapter 6 presents the names of those who submitted public comment during the scoping period. Chapter 7 contains the list of preparers, references and glossary. Copies of supporting documents are on file in the administrative record in the Montana Department of Environmental Quality (DEQ) office in Helena, and at the U.S. Department of the Interior, Bureau of Land Management (BLM) Field Office in Butte, Montana.

1.2 PURPOSE OF AND NEED FOR THE SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

MEPA and NEPA policies are intended to ensure that governmental agencies make informed and deliberate decisions, while expanding the public right to participate in those decisions. Agencies are required to carry out these policies through the use of a systematic, interdisciplinary analysis on actions that affect the human environment. DEQ and BLM have determined that under MEPA and NEPA regulations and in accordance with the procedures set forth in the Metal Mine Reclamation Act (MMRA), it was necessary for the agencies to conduct an analysis to thoroughly investigate potential environmental impacts of a modified proposal to backfill the GSM open pit (GSM, 2002). The revised pit reclamation plan was submitted by GSM on December 2, 2002, as ordered by DEQ on October 24, 2002. This SEIS represents that required additional systematic analysis. The purpose of this SEIS is to evaluate the potential environmental impacts associated with the Proposed Action and alternative pit reclamation plans at the mine.

The Proposed Action evaluated in this document is a pit backfill proposal modified by the agencies' comments and GSM's responses to those comments (See GSM, December 2002; DEQ/BLM, January 14, 2003; GSM, April 23, 2003; DEQ/BLM, June 16, 2003; GSM, August 8, 2003; DEQ/BLM, August 27, 2003; GSM, September 17, 2003; DEQ/BLM, November 18, 2003; GSM, December 19, 2003) including the revised acreages submitted as part of GSM's 2003 Annual Report, June 2004. The Proposed Action involves backfilling the pit when mining operations cease at GSM. In this document, the Proposed Action is referred to as the "Partial Pit Backfill With In-Pit Collection" Alternative.

Reclamation alternatives for the GSM pit were evaluated in a Draft EIS issued in 1997 (DEQ and BLM, 1997) and a Final EIS issued in 1998. Some important conditions have changed since that time, resulting in an agency decision to prepare this SEIS as a supplement to the 1998 document. Six years later, the pit design has changed, underground mining has been approved and completed, and large portions of the waste rock dump complexes have been reclaimed. These differences are due to mining operations that have taken place during the past 6 years, which are in accordance with GSM's approved operating permit and agency-approved minor revisions to that permit. Also, additional research and evaluation has provided more information pertaining to the geology, hydrology and geochemistry of the mine area.

1.3 OBJECTIVES

The objectives of the analyses included in this SEIS are as follows:

- Comply with the June 2002 judgment of the Montana First Judicial District Court (District Court) to implement the partial pit backfill reclamation plan at GSM in accordance with the procedures set forth in MMRA;
- Consider reasonable alternatives to the partial pit backfill plan as required by MEPA and NEPA;
- Evaluate the partial pit backfill plan and alternatives to develop a pit reclamation plan that will comply with existing federal, state, and local laws;
- Provide the public with an opportunity to comment on the SEIS for reclamation of the pit;
- Provide the regulatory agencies' decision makers with the best scientific information on which to base their decision; and,
- Minimize adverse impacts to existing, approved reclamation plans for the rest of the mine site and long-term water treatment plans.

1.4 PROJECT LOCATION AND RELEVANT HISTORY

1.4.1 Project Location

GSM is located approximately 5 miles northeast of Whitehall, Montana (Figure 1-1). Access to the site is via State Highway 2 East, located adjacent to Interstate 90. Existing mining operations are located in: Sections 19, 20, 28, 29, 30, 32, and 33 of Township 2 North, Range 3 West; Section 6 in Township 1 North, Range 3 West; and Sections 24 and 25 in Township 2 North, Range 4 West in Jefferson County, Montana.

1.4.2 Mineral and Surface Ownership

Golden Sunlight Mines, Inc. is the owner and operator of the existing and proposed operations. The corporate address is: Golden Sunlight Mines, Inc., 453 Montana Highway 2 East, Whitehall, Montana 59759.

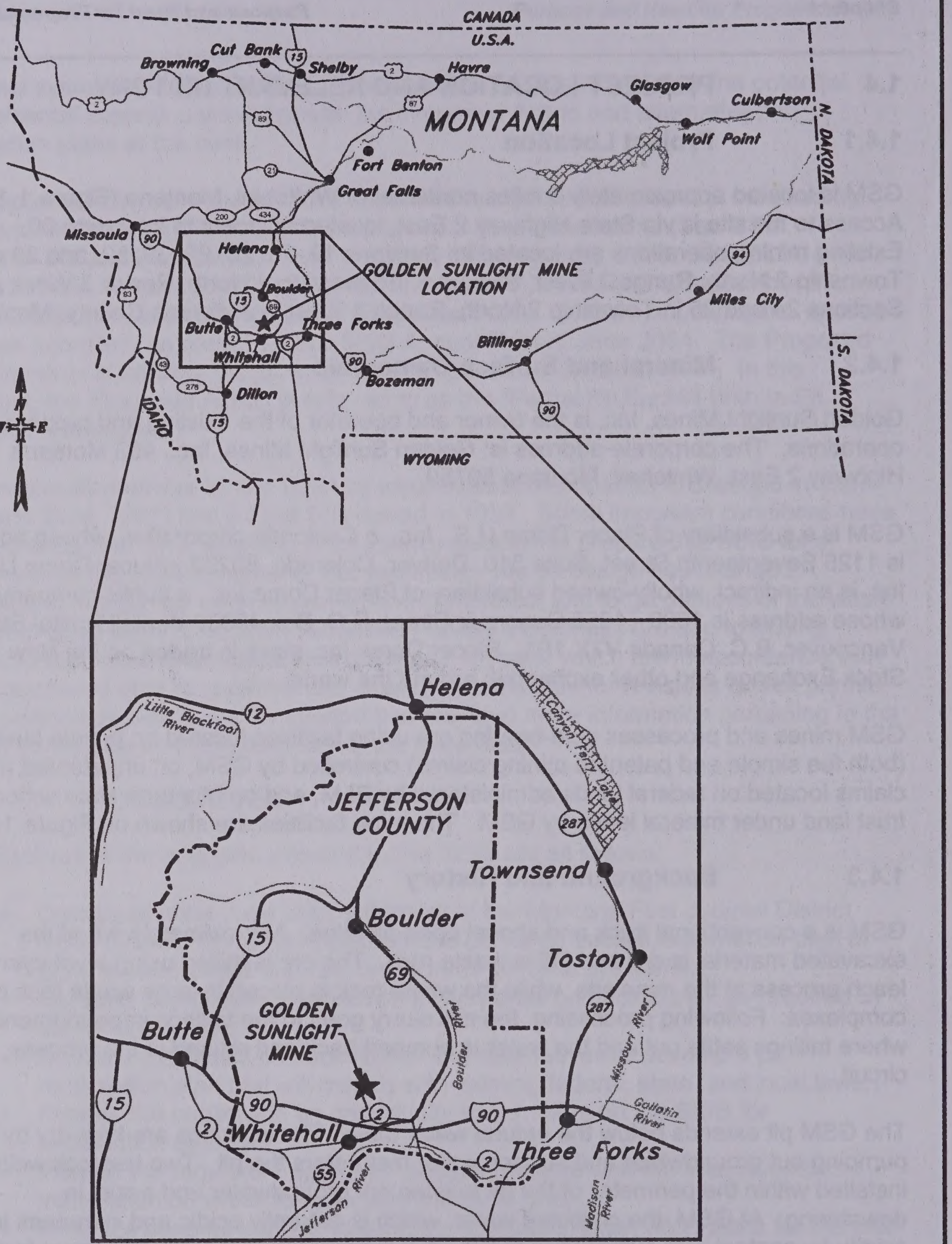
GSM is a subsidiary of Placer Dome U.S., Inc., a California corporation, whose address is 1125 Seventeenth Street, Suite 310, Denver, Colorado, 80202. Placer Dome U.S., Inc. is an indirect, wholly-owned subsidiary of Placer Dome Inc., a public company, whose address is 1600 - 1055 Dunsmuir Street, P.O. Box 49330 Bentall Postal Station, Vancouver, B.C. Canada V7X 1P1. Placer Dome Inc. stock is traded on the New York Stock Exchange and other exchanges around the world.

GSM mines and processes gold-bearing ore using facilities located on private lands (both fee simple and patented mining claims) controlled by GSM, on unpatented mining claims located on federal lands administered by BLM, and on Montana state school trust land under mineral lease by GSM. The mine facilities are shown on Figure 1-2.

1.4.3 Background and History

GSM is a conventional truck and shovel open pit mine. Approximately 1/6 of the excavated material is ore and 5/6 is waste rock. The ore is milled using a vat cyanide leach process at the mine site, while the waste rock is placed in large waste rock dump complexes. Following processing, the mill slurry goes to the tailings impoundment where tailings settle out and the water is pumped back and reused in the process circuit.

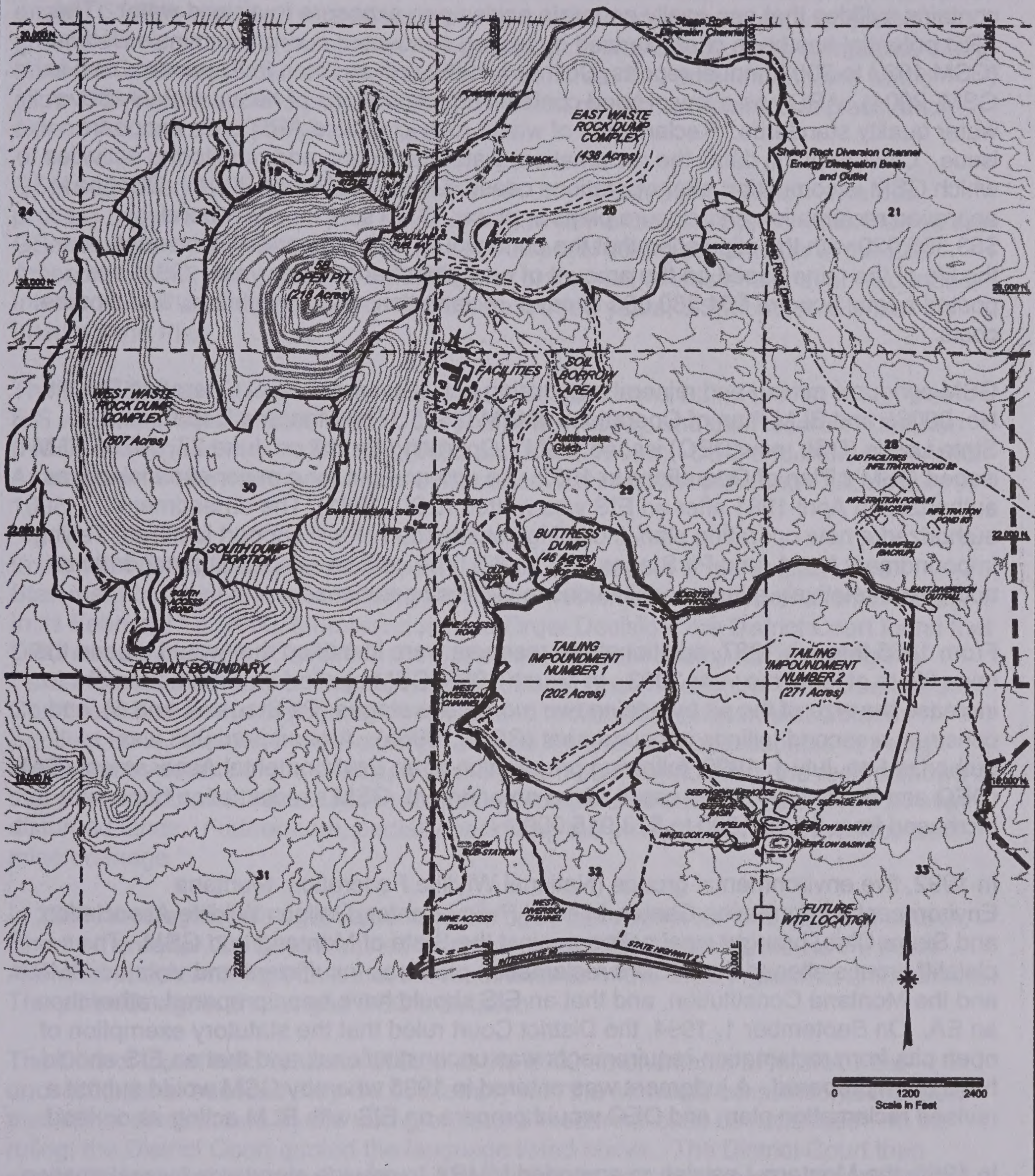
The GSM pit extends below the natural water table. The workings are kept dry by pumping out groundwater and surface water that enters the pit. Two bedrock wells are installed within the perimeter of the pit to intercept groundwater and assist in dewatering. At GSM, the collected water, which is naturally acidic and increases in acidity by contact with sulfide rock in the pit, is pumped to an on-site treatment facility where the acidity is neutralized and metals are removed before the water is used in the milling process or discharged.


CANADA
U.S.A.
MONTANA
Browning
Cut Bank
Shelby
Havre
Glasgow
Culbertson
Wolf Point
Fort Benton
Great Falls
Missoula
Helena
Boulder
Butte
Whitehall
Three Forks
Dillon
Bozeman
Billings
Miles City
GOLDEN SUNLIGHT MINE LOCATION
N. DAKOTA
S. DAKOTA
WYOMING
IDAHO
N
W
E
2
15
87
89
21
200
434
90
83
69
43
278
94
Little Blackfoot River
12
Canyon Ferry Lake
287
JEFFERSON COUNTY
Townsend
Toston
GOLDEN SUNLIGHT MINE
Boulder River
Missouri River
Gallatin River
Madison River
Jefferson River
55

GENERAL LOCATION MAP

Figure 1-1 GenLoc BW.dwg

FIGURE 1-1


30,000 N.
Sheep Rock Diversion Channel
POWDER MAG.
EAST WASTE ROCK DUMP COMPLEX (438 Acres)
CABLE SHACK
Sheep Rock Diversion Channel Energy Dissipation Basin and Outlet
24
20
21
READYLINE #3 FUEL BAY
READYLINE #2
MIDAS BOCELL
Sheep Rock Draw
26,000 N.
58 OPEN PIT (218 Acres)
FACILITIES
SOIL BORROW AREA
WEST WASTE ROCK DUMP COMPLEX (507 Acres)
Rattlesnake Gulch
28
LAD FACILITIES
INFILTRATION POND #2
29
30
CORE SHEDS
ENVIRONMENTAL SHED
SHED
INFILTRATION POND #1 (BACKUP)
INFILTRATION POND #3
22,000 N.
BUTTRESS DUMP (46 Acres)
DRAINFIELD (BACKUP)
SOUTH DUMP PORTION
SOUTH ACCESS ROAD
BOOSTER PUMPHOUSE
EAST DIVERSION OUTFALL
MINE ACCESS ROAD
TAILING IMPOUNDMENT NUMBER 1 (202 Acres)
TAILING IMPOUNDMENT NUMBER 2 (271 Acres)
PERMIT BOUNDARY
WEST DIVERSION CHANNEL
18,000 N.
SEEPAGE PUMPHOUSE
WEST SEEPAGE BASIN
EAST SEEPAGE BASIN
PIPELINE
OVERFLOW BASIN #1
WHITLOCK PAD
OVERFLOW BASIN #2
GSM SUB-STATION
31
32
33
FUTURE WTP LOCATION
WEST DIVERSION CHANNEL
MINE ACCESS ROAD
STATE HIGHWAY 2
INTERSTATE 90
22,000 E.
0
1200
2400
Scale in Feet

MINE FACILITIES
AS OF DECEMBER 2003

FIGURE 1-2

Figure 1-2 Facilities.dwg

Most waste rock at GSM has potential to create "acid rock drainage" (ARD), because it contains sulfides that can easily generate acids upon exposure to air and water. The ARD potential has been characterized by testing conducted during the mine's lifetime (GSM 1982 to 2003 annual reports; Dollhopf, 1989; and as listed in Appendix OP-6 in GSM, 2004). ARD has a low pH and contains concentrations of heavy metals above water quality standards. Reclamation of waste rock to reduce ARD is an important issue. Closure plans detail the reclamation, water treatment, and monitoring activities to which GSM is committed after operations cease (GSM, 1995b and 2004). GSM has approved reclamation and closure plans in place. GSM's reclamation bond is $63,355,020 with the stipulation that the bond would be incrementally increased over the life of the mine based on the amount of new disturbance each year. GSM has posted a total bond of $54,380,000 to cover reclamation, water treatment, and closure costs.

GSM conducts mining and mineral processing activities under DEQ Operating Permit No. 00065 and BLM Plan of Operations #MTM82855. The Montana Department of State Lands (DSL, now DEQ) issued GSM's Operating Permit on June 27, 1975. BLM issued GSM's Plan of Operations in 1982. An amendment for a major expansion was authorized in April 1981 after an EIS was written (DSL, 1981). The amendment authorized a new operating plan, including construction of mill support facilities, Tailings Impoundment No. 1, and Pit Stages 1, 2, and 3. The next seven permit amendments addressed relatively minor modifications to GSM's operations.

From 1985 through 1987, additional ore reserves were identified that would extend the mine life to at least the year 2003. In March 1988, GSM applied for an amendment to increase the size of the pit by adding two more mine stages (Pit Stages 4 and 5), and construct a second tailings impoundment (GSM, 1995a). Amendment 008 was authorized on July 1, 1990, following preparation of an Environmental Assessment (EA) (DEQ and BLM, 1990). As a result of the amendment, GSM's reclamation bond was increased from $1,750,000 to $23,915,000.

In 1992, five environmental groups (National Wildlife Federation, Montana Environmental Information Center, Mineral Policy Center, Gallatin Wildlife Association, and Sierra Club) brought legal action against the State of Montana and GSM. The plaintiff groups alleged that GSM's reclamation plan was insufficient and violated MMRA and the Montana Constitution, and that an EIS should have been prepared rather than an EA. On September 1, 1994, the District Court ruled that the statutory exemption of open pits from reclamation requirements was unconstitutional, and that an EIS should have been prepared. A judgment was entered in 1995 whereby GSM would submit a revised reclamation plan, and DEQ would prepare an EIS with BLM acting as co-lead.

In 1995, the Montana Legislature amended MMRA to provide standards for reclamation of open pits. In part, the amendment required reclamation to specified conditions "to the extent feasible". The enacting legislation contained a Statement of Intent that listed the factors that the Legislature intended DEQ to consider in determining feasibility.

At that time, GSM decided to seek another permit amendment. The amendment would enable GSM to replace the previously planned waste rock dump area, lost due to ground movement in 1994, by expanding its existing waste rock dump complexes in the northeast and west sides of the operating permit area. The amendment also would allow GSM to expand the pit, extend the mine life, modify its reclamation plans, and extend the operating permit boundary.

GSM submitted the amendment application in July 1995 (GSM, 1995b). The EIS process began in October 1995. DEQ and BLM authorized an Interim Mine Plan so that GSM could continue mining and waste rock disposal during preparation of the EIS. Amendment 009 was issued in April 1997 for placement of waste rock at an expanded Interim Mine Plan Dump location. For the next three years, GSM operated under the Interim Mine Plan.

The Draft EIS was completed in November 1997 (DEQ and BLM, 1997b). The Final EIS was completed in April 1998 (DEQ and BLM, 1998a), and the Record of Decision (ROD) was signed in June of 1998 (DEQ and BLM, 1998b). DEQ and BLM authorized Amendment 010, which extended the life of active mining through Stage 5B, on July 9, 1998.

In the 1998 ROD, DEQ and BLM applied the factors set out in the Legislature's Statement of Intent and selected the No Pit Pond Alternative for reclamation of the pit. In its February 16, 2000, Memorandum and Order Decision, the District Court found that DEQ erred by using the factors in the Statement of Intent and by not choosing the Partial Backfill Alternative. The District Court also found, "Today, the record before the Court reveals that the major environmental and reclamation concerns at Golden Sunlight Mine, specifically, the open pit and the highwall, are best capable of being reclaimed by means of the partial pit backfill alternative. In addition, the record shows that partial pit backfill reclamation will provide comparable utility and stability with other disturbed lands. Furthermore, partially backfilling the pit can significantly reduce acid mine drainage."

In 2000, the Legislature again amended the open pit reclamation provisions of MMRA. Shortly thereafter, DEQ reexamined its previous decision imposing the No Pit Pond Alternative, determining that it met the requirements of the 2000 legislative amendment. The plaintiffs again challenged DEQ's decision.

The District Court held in March 2002 that the 2000 amendments to MMRA were unconstitutional because they did not comply with the Montana constitutional mandate that "all lands disturbed by the taking of natural resources shall be reclaimed". In its ruling, the District Court quoted the language listed above. The District Court then stated "that record has not changed". The District Court subsequently ordered DEQ to immediately begin implementation of the partial pit backfill reclamation plan at GSM in accordance with the procedures set forth in MMRA.

In 2003, the Montana Legislature again amended the law pertaining to the reclamation of open pits and made the amendment applicable to the GSM operation. Subsection 82-4-336(9) now provides that:

> "(c) The use of backfilling as a reclamation measure is neither required nor prohibited in all cases. A department decision to require any backfill measure must be based on whether and to what extent the backfilling is appropriate under the site-specific circumstances and conditions in order to achieve the standards described in subsection (9)(b)."

Subsection 82-4-336(9)(b) provides that the highwall and pit must be reclaimed to a condition:

> (i) of stability structurally competent to withstand geologic and climatic conditions without significant failure that would be a threat to public safety and the environment;
> (ii) that affords some utility to humans or the environment;
> (iii) that mitigates post-reclamation visual contrasts between reclamation lands and adjacent lands; and,
> (iv) that mitigates or prevents undesirable offsite environmental impacts.

Under the Partial Backfill Alternative evaluated in the 1998 Final EIS and not selected in the 1998 ROD, the backfill material for the pit would have come from both the West and the East Waste Rock Dump complexes. Virtually all of the West Waste Rock Dump Complex is located on land owned by the U. S. and managed by BLM. Portions of the pit and the East Waste Rock Dump Complex are also BLM-managed federal lands. On September 6, 2002, BLM notified DEQ that the Partial Backfill Alternative may result in "unnecessary or undue degradation of public lands" and that, before GSM can be required to reclaim under the Partial Backfill Alternative on federal land, BLM must prepare a supplemental review pursuant to NEPA and approve the modification to the reclamation plan.

On October 24, 2002, DEQ, acting pursuant to the June 27, 2002, District Court judgment, ordered GSM to submit a modified partial pit backfill plan to meet the requirements of MMRA, its implementing rules, and the judgment of the District Court. The plan was to take into consideration current conditions at the mine site and address compliance with the Montana Water Quality Act. GSM submitted a proposed partial pit backfill plan on December 2 (GSM, 2002).

The proposed partial pit backfill plan addresses the following site conditions at the mine that have changed since the 1998 ROD was issued:

- GSM has implemented a modified pit design resulting in a different pit configuration than was used in the 1998 evaluations;

- The original Partial Backfill Alternative, which was evaluated in 1997, called for a large portion of fill material to be obtained from the West Waste Rock Dump Complex. That waste rock dump has since been reclaimed;
- GSM has mined underground under the pit, which could affect backfill operations;
- Additional technical information and evaluation was required to assess the waste rock backfill effects on compliance with the Montana Water Quality Act; and
- GSM has received numerous permit revisions to allow minor modifications to GSM's operations. These revisions cover a variety of activities such as road building, well construction, research projects, and water disposal.

In order to meet the requirements of the October 24, 2002 Order, GSM proposed a Partial Pit Backfill With In-Pit Collection Plan. This is analyzed as the Proposed Action in this SEIS (see Section 1.5). This SEIS is tiered to the 1997 Draft EIS and the 1998 Final EIS.

1.4.4 Current Approved Plan

The 1998 ROD approved the No Pit Pond Alternative as modified by the Return Diversion Alternative (Map II-2, 1997 Draft EIS). The ROD contains various stipulations that were applied to the permit in order to implement the amendment.

As approved in 1998, the pit would be mined to the 4,700-foot elevation. Minor revision 03-001 to deepen the pit to the 4,650-foot elevation was approved by the agencies in 2003 (DEQ and BLM, 2003). The pit design would essentially remain as it is currently permitted (Figure 2-1). Mining operations would continue at least until 2006.

After mining operations cease, GSM would have to implement its closure plan (GSM, 1995b, 2004). The current approved reclamation plan for the pit would involve placing about 475,000 cubic yards (713,000 tons) of waste rock back into the pit to bring the pit bottom to the 4,800-foot elevation (1998 ROD, Stipulation 010-8; Figure II-3, 1997 Draft EIS; DEQ bond calculation, 1998). In addition, 26 acres of pit roads and benches that could be accessed would be covered with soil and revegetated. Otherwise, the pit would remain open and not be backfilled.

A waste rock sump in the backfill would collect all water that enters the pit. Water collected in the sump would be pumped from two dewatering wells to the permanent water treatment plant as needed, treated and discharged (Figure 1-2). The dewatering system would maintain the groundwater level as low as possible in the backfill, preventing the formation of a pit pond and maintaining the pit as a hydrologic sink. According to the 1997 Draft EIS Chapter IV, Section IV.B.6.b, approximately 102 gpm would need to be pumped out continuously.

The above-described pit reclamation plan was approved in 1998 by the regulatory agencies. This decision has been legally challenged, as explained in Section 1.4.3.

1.5 PROPOSED ACTION

As ordered by DEQ, GSM provided the details of a modified Partial Pit Backfill With In-Pit Collection Plan, which is the Proposed Action in this SEIS (GSM, 2002). The Proposed Action includes reclaiming the pit by partially backfilling it to the level at which surface water would freely drain from the pit ("daylight level") on the east side of the pit and covering the highwall (Figure 2-4). The current operating permit allows mining through Stage 5B, which was estimated in the 1998 Final EIS to last through 2006. Groundwater and surface water that would naturally flow into the pit would be collected, pumped, and treated at the water treatment facility (Figure 1-2). See Chapter 2 for details of this alternative.

The major differences from the Partial Backfill Alternative (Figure II-4, 1997 Draft EIS) evaluated in the 1997 Draft EIS are:

- Based on the current approved mine designs, the pit configuration has been modified, including the bottom elevation and the elevation of the eastern key cut, the low point on the pit rim where the haul road enters the pit. The elevation of the key cut is 5,350 feet, and, therefore, the pit would have to be backfilled to this level to allow surface water to drain away from the pit area after reclamation. The final pit depth will be the 4,525-foot elevation as proposed or at least the 4,650-foot elevation approved by DEQ in minor revision 03-001, which affects the quantity of backfill material required;
- No waste rock material would be removed from the West Waste Rock Dump Complex;
- Cast blasting and dozing would be used to reduce the upper pit highwall rather than hauling all backfill material from the West Waste Rock Dump Complex;
- Before backfilling the pit to the key cut, 100 feet of crusher reject would be placed in the pit to the 4,625-foot elevation to aid in collecting water for pumping; and,
- A 3-foot soil cover system approved for the waste rock dump complexes is proposed for the cover on the backfill material.

1.6 REGULATORY AUTHORITY RULES AND RESPONSIBILITIES

1.6.1 Applicable Regulatory Requirements

1.6.1.1 Introduction

Table 1-1 lists the permits, licenses, and reviews that are required at GSM. The air quality permit would not require modification because the mining and milling rates would not change. Consultation with the Montana State Historic Preservation Office (SHPO) regarding cultural resources has been initiated by BLM. GSM's updated Storm Water Pollution Prevention Plan has been approved by DEQ.

Table 1 - 1 Mine Permits, Licenses, and Reviews

Granting Agency	Permit/Approval
BLM, Butte Field Office	Approval of Plan of Operations.
U.S. Fish & Wildlife Service (USFWS)	Review under the Endangered Species Act.
Environmental Protection Agency (EPA)	SEIS review under the Clean Air Act.
U.S. Army Corps of Engineers	Permit under Section 404 of the Clean Water Act
DEQ	Administering MMRA and MEPA; requiring bonding for reclamation of disturbed lands and water treatment; ensuring compliance with state water, air, and hazardous waste regulations; and issuing water discharge and air quality permits.
State Historic Preservation Office (SHPO)	Review under the National Historic Preservation Act and 36 CFR 800 regarding protection of cultural/historic resources.
Jefferson County Disaster & Emergency Relief Coordinator	Review of Floodplain and Emergency Operations Plans regarding uncontrolled releases of hazardous substances.
Jefferson County Weed District	Review for control and prevention of noxious weed infestations.

1.6.1.2 Montana Department of Environmental Quality

DEQ administers MEPA, MMRA, the Montana Hazardous Waste Act, the Clean Air Act of Montana, and the Montana Water Quality Act. DEQ is responsible for investigating the environmental impacts associated with pit reclamation at GSM in accordance with MEPA and the EIS process, and for evaluating compliance with MMRA.

1.6.1.3 U.S. Bureau of Land Management

BLM manages federally owned lands under its jurisdiction and federally owned minerals. GSM's use of public land must conform to BLM's surface management regulations (43 CFR, Subpart 3809) as well as various federal statutes, including NEPA, the Mining and Mineral Policy Act of 1970, the General Mining Laws, and the Federal Land Policy and Management Act of 1976. BLM must review plans for development on BLM-administered land. The Proposed Action was evaluated for conformance with BLM's Headwaters Resource Management Plan (RMP) Butte and Lewistown Districts

(BLM, 1984). Livestock grazing, wildlife habitat, recreation, and mineral resource development are land uses identified in the RMP as appropriate for the project area.

In addition to the requirements of MEPA, the NEPA process was followed during the preparation of the SEIS to ensure:

- Adequate provisions are included to prevent unnecessary or undue degradation of public lands and to protect the non-mineral resources on public lands.
- Measures are included to provide for reclamation of disturbed areas.
- BLM's NEPA Handbook (H-1790, Appendix 5) requires that all EISs address certain Critical Elements of the Human Environment. These critical elements are presented below. Any elements that do not occur within the GSM permit area and would not be affected are indicated in Issues Considered but Not Studied in Detail (Section 1.7.3), and those elements are not discussed further in the SEIS.

This elimination of non-significant issues follows the CEQ guidelines as stated in 40 CFR 1500.4. Conformance with the Headwaters Resource Area RMP is ensured and compliance with applicable substantive state and federal laws is achieved through following the CEQ guidelines. BLM is responsible for Section 106 consultation with SHPO in regard to the following on BLM lands:

- The eligibility of cultural resources located on BLM lands within and near the permit area; and,
- The effect of approval of the Proposed Action on eligible cultural resources.

Other issues that BLM must consider and mitigate impacts to, if necessary, include:

- Areas of critical environmental concern;
- Prime or unique farm lands;
- Floodplains;
- Native American religious concerns;
- Threatened or endangered species;
- Solid or hazardous wastes;
- Drinking water/groundwater quality;
- Wetlands/riparian zones;
- Wild and scenic rivers;
- Wilderness;
- Environmental Justice; and,
- Invasive, non-native species.

All of the issues listed above were considered, although some were not considered in detail as described in this document.

1.6.1.4 Participating Agencies

The lead agency for preparation of the SEIS is DEQ, with BLM acting as co-lead. BLM consulted with USFWS, pursuant to the Endangered Species Act, and SHPO, pursuant to the National Historic Preservation Act, during the preparation of this SEIS.

EPA will review this SEIS pursuant to the federal Clean Air Act, and also participated in the Multiple Accounts Analysis (MAA) process (Robertson GeoConsultants, 2003).

1.6.2 Decisions To Be Made

The DEQ Director and the BLM Field Manager will use the SEIS to decide which pit reclamation alternative to implement and what mitigation measures, if any, to add to the selected alternative.

1.6.3 Relationship to Other Environmental Planning Documents

Numerous documents were reviewed in the development of this Draft SEIS, some of which are not listed in Chapter 7. The MEPA/NEPA and other documents pertinent to GSM that influenced this Draft SEIS are listed in Table 1-2.

Table 1 - 2 Related Environmental and Planning Documents

Document Title	Author	Date
Cultural Resource Class III Inventory Report Number 80-MT-070-075-11,12	Miller, B., BLM	August 6, 7, 1980
Section 32 Tailing Disposal Facility, Golden Sunlight Project, Vol. I. Report Submitted to Golden Sunlight Mine	Sergent, Hauskins & Beckwith, Geotechnical Engineers	September 14, 1981
Cultural Class III Inventory Report Number 82-MT-070-075-14	Taylor, J., BLM	1982
Cultural Class III Inventory Report Number 83-MT-070-075-01, 09	Taylor, J., BLM	1982, 1983
Golden Sunlight Mines, Inc. Annual Reports.	GSM	1990-2003
Hydrogeologic Evaluation, Tailing Disposal Facility, Golden Sunlight Project, Whitehall, Montana	Sergent, Hauskins & Beckwith, Geotechnical Engineers	October 24, 1985
Cultural Class III Inventory Report Number 85-MT-070-075-25	Taylor, J., BLM	1985

Document Title	Author	Date
Cultural Resource Investigation and Assessment of the Golden Sunlight Mine	Herbort, D. State of Montana Land Exchange	1985
Hydrogeologic Evaluation, Tailing Disposal Facility, Golden Sunlight Project, Whitehall, Montana	Sergent, Hauskins & Beckwith, Geotechnical Engineers	August 5, 1986
Hydrogeologic Evaluation, Golden Sunlight Project, Whitehall, Montana	Sergent, Hauskins & Beckwith, Geotechnical Engineers	April 23, 1987
Investigation of Golden Sunlight Mine's Tailings Pond Leak and Alleged Impact to Downgradient Domestic Water Supplies	DSL	May 15, 1987
Site Visit Report, Rock Waste Dump and Midas Slump	Seegmiller International Mining Geotechnical Consultants	1987, 1988
Results of an Investigation of the High Nitrate Values in Wells Surrounding the Golden Sunlight Mine	DSL	1988
Final Design Development Report, East Tailing Disposal Facility, Golden Sunlight Mine Vol. II. Submitted to Golden Sunlight Mine	Sergent, Hauskins & Beckwith, Geotechnical Engineers	July 19, 1988
Soil Survey of the Golden Sunlight Mine Proposed Expansion Area	Ottersberg, B.	1988
Hydrogeologic Evaluation, Golden Sunlight Project, Whitehall, Montana	Sergent, Hauskins & Beckwith, Geotechnical Engineers	February 10, 1989
Hydrogeologic Evaluation to Support Environmental Assessment, Golden Sunlight Project, Whitehall, Montana	Sergent, Hauskins & Beckwith, Geotechnical Engineers	February 27, 1989
Relationship of the Golden Sunlight Mine To the Great Falls Tectonic Zone	Foster, F. and Chadwick, T.	1990
A Fluid Inclusion, Stable Isotope, and Multi- Element Study of the Golden Sunlight Deposit. M.S. Thesis, Iowa State University	Paredes, M.M.	1990
Should Pits be Filled? Oregon Geology, Volume 52, No. 4, pp. 82-83	Throop, A.	1990
Cultural Resource Inventory for the Golden Sunlight Mine Expansion Area	Peterson, R.R. Western Cultural Resource Management, Inc	1991

Document Title	Author	Date
Geology and General Overview of the Golden Sunlight Mine	Foster, F.	1991
Jefferson County Montana 1993 Comprehensive Plan	Jefferson County, Planning Board	1993
Golden Sunlight Mines, Inc. Tailings Impoundment No. 1 Post-Closure Settlement.	Knight Piesold Ltd.	1993
Soil Baseline Study, Golden Sunlight Mine.	Houlton, H.M. and Noel, R.D. Westech Technology and Engineering	1994-1995
Class 1 Paleontologic Literature and Locality Search for the Golden Sunlight Mine Expansion Project	Lindsey, K.D. Western Cultural Resource Management	September 20, 1994
Report from F. Foster of GSM to S. Olsen of DSL and J. Owings of BLM, Regarding Ground Movement Remediation	Foster, F.	December 23, 1994
Class III Cultural Resource Inventory of Approximately 3,277 Acres for Golden Sunlight Mine	Peterson and Mehls	1994
Investigation and Evaluation of the Earth Block Movements at the Golden Sunlight Mine. Reports submitted to Golden Sunlight Mine on various dates	Golder, Associates Ltd.	January 10 1995-April 4 1996
Golden Sunlight Mines, Inc. Hard Rock Mining Permit Application and Plan of Operations for an Amendment to Operating Permit 00065	GSM	Five volumes dated August 25, 1995 with five revisions to May 23, 1996
Summary of the Geology and Environmental Programs at the Golden Sunlight Mine	Foster, F. Smith, T.	1995
Baseline Vegetation Inventory, Phase 2, GSM Permit Area	Westech	1995
Final Summary of Reclamation Monitoring Program for Waste Rock Facilities and Recommendations for Final Reclamation	Schafer and Associates	1995

Document Title	Author	Date
Evidence for a Magmatic Hydrothermal to Epithermal Origin for the Golden Sunlight Gold-Silver Telluride Deposit	Spry, P.G., Paredes, M.M., Foster, F., Truckle, J., and Chadwick, T.	1995
Hydrogeologic Investigation of the Golden Sunlight Pit. Golden Sunlight Mine, Jefferson County, MT	Hydrometrics	1995 (revised 1996)
Predictive Modeling of Moisture Movement in Engineering Soils Covers for Acid Generating Mine Waste. M.S. Thesis, U. of Saskatchewan	Swanson, D.A.	1995
Interim Dump Plan (approved by DEQ and BLM in 1995 & 1997)	GSM	(two minor revisions in '95 and '97)
Cultural Resource Inventory of 340 Acres and Testing/ Evaluation of Eight Sites for Golden Sunlight Mine Land Exchange	Peterson, R.R. Western Cultural Resource Management, Inc	1996
Formation of Ferricretes from Acid Rock Drainage at Golden Sunlight Mines, Jefferson County, MT. M.S. Thesis in Geoscience, Montana Tech of the University of MT, Butte	Taylor, E.	May 1997
Report on Water Quality Trends in No. 1 Impoundment Area	Hydrometrics	1997
Review of Documents Concerning Research at Golden Sunlight Mine	Bennett, J.W.	1997
Draft Environmental Impact Statement Golden Sunlight Mine	DEQ and BLM	November 1997
Water Quality Regulatory Compliance and Application for Source Specific Groundwater Mixing Zone, Golden Sunlight Mines	GSM	January 1998
Final EIS Amending and Adopting the Draft Environmental Impact Statement for Golden Sunlight Mine	DEQ and BLM	April 1998
Record of Decision for the Proposed Mine Expansion Golden Sunlight Mine Permit Amendments 008 and 010 to Operating Permit 00065	DEQ and BLM	June 1998

Document Title	Author	Date
Golden Sunlight Mine West Waste Rock Pile Hydrologic Monitoring and Reclamation Study – Final Monitoring Report. In GSM 2000 Annual Report, Volume II, Appendix AR-00-1.3.	Schafer Limited	April 16, 2001
Golden Sunlight Mines, Inc. Operating and Reclamation Plan. A Summary of the Golden Sunlight Mine Operations and Environmental Programs	GSM	2001
Pit Hydrogeology Investigation	URS Corp.	December 4, 2001
Preliminary Report of Environmental Risks of Proposed Backfilling of Golden Sunlight Pit.	Hydrologic Consultants, Inc. (prepared for GSM)	November 26, 2002
Golden Sunlight Mines, Inc. Partial Pit Backfill Plan as Ordered by Montana Dept. of Environmental Quality on October 24, 2002	GSM	December 2, 2002
DEQ Internal Memo – Comments with respect to geochemistry - Golden Sunlight Mine (GSM) Revised Partial Pit Backfill Plan, Dec. 1, 2002	Laura Kuzel, DEQ	December 23, 2002
DEQ Internal Memo – Comments with respect to water quality– Golden Sunlight Mines, Inc. Partial Pit Backfill Plan As Ordered by DEQ on Oct. 24, 2002	George Furniss, DEQ	December 30, 2002
DEQ/BLM Deficiency Review of GSM Partial Pit Backfill Plan	DEQ and BLM	January 14, 2003
Environmental Data Compilation for the Open Pit Area and Potential Pit Backfill Material	Kathy Gallagher	March 21, 2003
Response to DEQ/BLM Deficiency Review of GSM Partial Pit Backfill Plan	GSM	April 23, 2003
Pit Highwall Seeps	Kathy Gallagher	May 28, 2003
DEQ/BLM Second Deficiency Review of GSM Partial Pit Backfill Plan	DEQ/BLM	June 16, 2003
Memorandum on Stepan Spring Water Quality	Kathy Gallagher	June 30, 2003
Response to DEQ/BLM Second Deficiency Review of GSM Partial Pit Backfill Plan	GSM	August 8, 2003

Document Title	Author	Date
DEQ/BLM Third Deficiency Review of GSM Partial Pit Backfill Plan	DEQ/BLM	August 27, 2003
Response to DEQ/BLM Third Deficiency Review of GSM Partial Pit Backfill Plan	GSM	September 17, 2003
Amendments to Operating Permit 00065, particularly Amendment 008	GSM	Various dates
Water Balance Model Technical Memo	Telesto	October 2003
Hydrologic Conceptual Model Technical Memo	Telesto	October 2003
Pit Backfill Geochemistry Technical Memo	Telesto	October 2003
Geotechnical Report for the Reclamation Alternatives for the Golden Sunlight Mine Pit Technical Memo	Telesto	October 2003
Feasibility Assessment Technical Memo	Telesto	October 2003
GSM SEIS Hydrology Support Document	HydroSolutions	October 2003
Pit Analog Study	Kathy Gallagher and Laura Kuzel	October 2003
DEQ/BLM Fourth Deficiency Review of GSM Partial Pit Backfill Plan	DEQ/BLM	November 18, 2003
Response to DEQ/BLM Fourth Deficiency Review of GSM Partial Pit Backfill Plan	GSM	December 19, 2003
DEQ/BLM Current Permit and Bond Status for Operating Permit 00065	DEQ	January 20, 2004
DEQ/BLM Completeness Letter of GSM Partial Pit Backfill Plan	DEQ/BLM	February 17, 2004
Bio Fouling Potential in Backfill Wells	Telesto	February 2004
Golden Sunlight Mines, Inc. 2004 Operating and Reclamation Plan.	GSM	June 2004
Golden Sunlight Mines, Inc. 2003 Annual Permit Report.	GSM	June 2004

1.7 PUBLIC PARTICIPATION PROCESS

1.7.1 Scoping

The scoping process is used to identify all issues relevant to the Proposed Action and to help develop alternatives to the Proposed Action. Efforts were made during preparation of this SEIS to involve members of the public and other agencies to define the issues and the scope of analysis.

A Notice of Intent (NOI) to prepare the SEIS was published in the Federal Register on May 7, 2003. The NOI invited scoping comments to be sent to DEQ and BLM through June 7, 2003. On July 1, 2003, a news release was issued to area newspapers, State of Montana Newslinks Service, and major interest groups. A public scoping meeting was held near the mine in Whitehall, Montana, on July 16, 2003. Approximately 165 members of the public attended the meeting, and public comments were recorded. As a result of the public scoping process, 75 comment letters were received by DEQ and BLM. Issues and concerns raised at the meeting and contained in the written comments were summarized for consideration in preparation of the SEIS. DEQ and BLM also attended a public informational meeting sponsored by the Whitehall Community Transition Advisory Committee in Whitehall on September 9, 2003, to update local residents on SEIS progress.

1.7.2 Multiple Accounts Analysis Process and Issues Studied in Detail

In an effort to systematize issue evaluation and alternative development and to involve the various agencies and stakeholder groups, DEQ and BLM decided to use the MAA process (Robertson GeoConsultants, 2003). The MAA process was developed for evaluation of land management alternatives as a means of comparing alternatives by weighing benefits and costs. It is particularly useful when projects are controversial because it allows for multi-stakeholder/multi-disciplinary teams to attempt reaching consensus by having opponents and proponents of the project work together. It also aids the consideration of possible reclamation measures, evaluation of the effectiveness of the reclamation alternatives, and revision of the alternatives to optimize their effectiveness.

During the MAA process, representatives from each of the agencies and stakeholder groups participated in a technical working group (TWG) to produce and evaluate alternatives. In this case, the TWG consisted of two representatives each from BLM, DEQ, GSM and its technical consultants, EPA, and, collectively, the five plaintiffs in the District Court action. Spectrum Engineering and its subcontractor, Robertson GeoConsultants, directed the TWG and the MAA process. The TWG met on May 16, June 18 to 19, July 2, and August 4 to 5, 2003. In addition to these meetings, two subgroups met to address the primary concerns including hydrology and geochemistry.

A local rancher attended the fourth MAA meeting and provided input from a public stakeholder viewpoint to the process.

An evaluation was performed to distinguish potentially significant issues from non-significant issues. Potentially significant issues are evaluated in detail in Chapter 4 of this environmental review, and rationale is presented in Section 1.7.3 for issues that were initially considered but then eliminated from detailed study. All issues identified through public input or identified through analysis are presented and summarized individually. While discussion of all identified issues is necessary for full disclosure of impacts under MEPA and NEPA, the issues do not necessarily correspond with, or are co-extensive to, the agencies' selection criteria under applicable federal and state law.

A number of concerns associated with the 1997 Draft EIS Partial Backfill Alternative that, prior to this SEIS, had not been raised or for which new information has become available have been identified. The issues studied in detail are presented in Table 1-3. Issues identified in Section 1.7.3 are not studied in detail in this SEIS because the issues have not changed since the 1998 Final EIS and no new data are available.

Table 1 - 3 Issues Studied In Detail

ISSUE GROUP	ISSUE	INDICATOR
Technical	Design & constructibility of the alternative	Proven design (done successfully at other places?)
Technical	Design & constructibility of the alternative	Ability to construct the alternative at GSM
Technical	Pit highwall	Pit highwall stability
Technical	Pit highwall	Pit highwall maintenance requirements
Technical	Backfill	Backfill maintenance requirements
Technical	Underground workings	Impacts to pit facilities due to subsidence related to underground mining
Technical	Groundwater/effluent management system	Operation requirements (number of wells)
Technical	Groundwater/effluent management system	Maintenance of capture points
Technical	Storm water runon/runoff management	Maintenance requirements (drainage channels off 2H:1V slopes)
Technical	Soil Cover	Soil cover maintenance requirements (erosion, revegetation)
Technical	Water treatment	Additional sludge management requirements
Technical	Water treatment	Additional operating requirements
Technical	Flexibility for future Improvements	Potential for utilization of new technologies
Environmental	Impacts to groundwater quality and quantity	Risk of impacts to groundwater quality and quantity in permit area

Environmental	Impacts to groundwater quality and quantity	Risk of violation of groundwater standards at permit boundary and impacts to beneficial uses of the Jefferson River alluvial aquifer
Environmental	Impacts to surface water quality and quantity	Impacts to springs, wetlands
Environmental	Impacts to surface water quality and quantity	Risk of violation of surface water standards and impacts to beneficial uses of the Jefferson River and Slough
Environmental	Reclamation plan changes	Surface disturbance
Environmental	Reclamation plan changes	Hazards to wildlife
Environmental	Reclamation plan changes	Total remaining unrevegetated acres
Socioeconomic	Safety	Risk to workers (reclamation and construction)
Socioeconomic	Safety	Risk to workers (long-term maintenance)
Socioeconomic	Safety	Risk to public safety
Socioeconomic	Mining employment	Potential employment from mining Stage 5B
Socioeconomic	Reclamation employment	Reclamation employment opportunities
Socioeconomic	Revenue from taxes	Potential tax revenues from mining Stage 5B
Socioeconomic	Revenue from taxes	Potential tax revenues from pit backfill
Socioeconomic	Mineral reserves and resources	Access to future mineral reserves/resources
Socioeconomic	Land use after mining	Suitability of land use after mining
Socioeconomic	Potential future burden	Potential future burden on society
Socioeconomic	Aesthetics	Visual contrast with adjacent lands
Socioeconomic	Potential future burden	Potential for future liabilities for GSM
Project Economics	Costs	Reclamation costs

Only those resources described as being affected in Chapter 3 or related to significant issues described in Chapter 1 are studied in detail in Chapter 4.

1.7.2.1 Technical Issues

1.7.2.1.1 Design and Constructibility of the Alternative

1.7.2.1.1.1 Proven Design

In engineering projects, the design and constructibility of the components are fundamental to the success of the project. Whether the components of the alternatives are considered proven within the mining industry must be considered.

1.7.2.1.1.2 Ability to Construct the Alternative at GSM

Whether the components of the alternatives can be constructed as designed at GSM must be determined and risks and uncertainties evaluated.

1.7.2.1.2 Pit Highwall

1.7.2.1.2.1 Pit Highwall Stability

The highwall of a pit is designed to remain sufficiently stable to permit the extraction of minerals during operations with the minimum amount of waste rock removal. As such, a highwall typically is not designed to remain completely stable for an indefinite period of time after closure. Over the long term, natural processes, such as chemical and physical weathering and/or localized seepage, could change rock characteristics in the pit highwall causing periodic raveling and sloughing as the highwall gradually evolves to a more stable configuration over time.

The potential for larger geologic failures, such as slide failures or wedge failures especially from earthquakes, which might cause large and sudden movements of material in the pit highwall, also exists in open pits and must be analyzed.

If backfill materials are introduced into the pit, highwalls that are covered across the pit from highwall to highwall will be more stable than pits that are not backfilled. After construction and as the backfill itself weathers and gradually becomes saturated, some settlement of the backfill could occur. Portions of the highwall not covered highwall to highwall on the 2H:1V slopes could still weather at a slower rate behind backfill materials.

1.7.2.1.2.2 Pit Highwall Maintenance Requirements

As discussed in Pit Highwall Stability, the pit highwall in alternatives that don't require backfill will continue to ravel over time. The amount of maintenance required to operate and maintain a pit dewatering system, access to the pit, reclamation covers, and storm water systems must be addressed because of pit highwall stability concerns.

1.7.2.1.3 Backfill

1.7.2.1.3.1 Backfill Maintenance Requirements

As discussed in Pit Highwall Stability, there are stability concerns with the backfill itself over time. The amount of maintenance required to operate and maintain a pit dewatering system depends on the amount of backfill, settling, weathering, and degree of saturation.

1.7.2.1.4 Underground Workings

1.7.2.1.4.1 Impacts to Pit Facilities Due to Subsidence Related to Underground Mining

Subsidence of underground workings over time may cause impacts to dewatering system function, worker safety, and future access to the pit and underground workings.

1.7.2.1.5 Groundwater/Effluent Management System

1.7.2.1.5.1 Operation Requirements (Number of Wells)

The potential risk of contamination to groundwater is more important than that to surface water at GSM. The risk to the overall groundwater system is affected by many factors.

The disturbances in the mineralized zone caused by mining and related activities at GSM have exposed a large volume of sulfides to the atmosphere, thereby accelerating the natural weathering processes and releasing more metals and sulfur (as sulfate) into water. This ARD, or acid rock drainage, is the largest environmental concern, or potential impact, as a result of mineral extraction at GSM.

Nearly all of the materials that have been mined at GSM are highly reactive, oxidize quickly and produce acid. Seepage from these materials will be acidic with high concentrations of dissolved sulfate and elevated levels of a variety of dissolved metals. Because the open pit mine extends deep into the groundwater system, water quality problems occurring inside the pit backfilled with ARD generating material could impact downgradient groundwater and adjoining aquifers.

Plans for the prevention or control of groundwater degradation must be evaluated with respect to short- and long-term utility and effectiveness. Due to potential impacts to groundwater and a limited potential impact to surface water resources, confidence that the controls chosen will work when implemented and continue to work far into the future is required.

Conceptually, capturing or treating contaminated water before it flows from the pit would eliminate the concern over flow paths from the pit and would limit the amount of water requiring treatment. If the alternative selected depends on wells for dewatering, the number of wells required and their depths will influence the manageability and dependability of the system as well as cost. As increasing amounts of backfill are placed inside the pit, operational limitations of managing wells in the acidic waste rock backfill could occur. Operating dewatering systems in hundreds of feet of backfill complicates water collection in backfilled pits. Operation of wells in acidic backfill or native materials around the pit needs to be addressed in various alternatives.

Alternatives that rely on capturing and treating impacted groundwater in order to protect the surrounding water resources will either need to control the water level in the pit or have the capacity to intercept a high percentage of the water escaping the pit. Backfilling the pit could complicate the collection system and make groundwater collection less certain. Issues related to pit dewatering include installing and maintaining dewatering systems safely in the acidic waters.

Safety issues differ between open pits and backfilled pits. Safety for workers is an issue in open pits.

Settling and compaction effects on dewatering systems were not evaluated previously in the 1997 Draft EIS. Issues related to flowpath control in a backfilled pit have been identified with and without in-pit dewatering systems:

- The backfill in the pit may not be completely free draining and could include zones of relatively low permeability;
- The non-homogeneous nature of the backfill could make it difficult to reduce water levels evenly and maintain a hydrologic sink; and,
- The presence of backfill could make it difficult to fully determine the flow paths of groundwater and the chemical reactions that are occurring.

1.7.2.1.5.2 Maintenance of Capture Points

Some problems with maintenance of capture points in the backfilled pit are discussed above. Attempting to manage a collection system located at the bottom of an open pit or in the existing underground workings accessed through the pit could also present long-term management and safety problems. There is a chance of deterioration of the pit highwall and subsidence of the underground workings over time. Although practices would be used to minimize hazards to workers, damage to equipment and maintaining access could be problematic.

Relying on capture of pit outflows at distances downgradient of the pit may introduce a larger degree of uncertainty and risk concerning the effectiveness of capturing all contaminated groundwaters and could require collection of a greater volume of groundwater. Maintenance of capture points needs to be addressed in all alternatives.

If capture systems cannot be maintained, contaminated groundwater could reach the Jefferson River alluvial aquifer.

1.7.2.1.6 Storm Water Runon/Runoff Management

1.7.2.1.6.1 Maintenance Requirements

The maintenance requirements for the storm water drainage channels off the reclaimed 2H:1V slopes caused by settling of the backfill must be evaluated.

1.7.2.1.7 Soil Cover

1.7.2.1.7.1 Soil Cover Maintenance Requirements

Reclamation of over 1,054 acres of disturbed land has been completed since the 1998 Final EIS (GSM 2003 annual report). This reclamation has resulted in a shortfall of stockpiled soil for reclamation activities. Although an adequate volume of soil exists for reclamation activities under the No Pit Pond Alternative in the 1997 Draft EIS, Chapter IV, Section IV.C.6.a, backfilling the pit would result in additional soil requirements.

Additional disturbance would be needed to obtain adequate soil under the modified backfill plans. Maintenance of the reclamation cover, erosion, and revegetation must be addressed for all alternatives.

1.7.2.1.8 Water Treatment

1.7.2.1.8.1 Additional Sludge Management Requirements

In the 1997 Draft EIS, Appendix C, the sludge from the water treatment plant would be deposited in cells in Tailings Impoundment No. 2 and reclaimed. The amount of additional sludge from treating pit water for each alternative must be evaluated.

1.7.2.1.8.2 Additional Operating Requirements

The dewatering systems needed for each alternative will affect the operating requirements of the water treatment plant and must be evaluated.

1.7.2.1.9 Flexibility for Future Improvements

1.7.2.1.9.1 Potential for Utilization of New Technologies

Flexibility for implementing improved water collection and treatment systems in the future must be evaluated. The potential for future improvements and utilization of new technologies must be considered for each alternative.

1.7.2.2 Environmental Issues

1.7.2.2.1 Impacts to Groundwater Quality and Quantity

1.7.2.2.1.1 Risk of Impacts to Groundwater Quality and Quantity in Permit Area

Groundwater flow direction has been mapped through previous studies using monitoring wells of various depths. Approximately 30 wells in the pit area are monitored quarterly. Groundwater flows into the pit from underneath and from all sides, with the steepest gradient on the north side. Understanding this flow system will be critical to the identification of potential impacts of reclamation alternatives.

Over time, the waste rock that is placed in the pit could be chemically and physically altered, causing pore waters with elevated concentrations of naturally occurring contaminants. The changing physical properties of the materials may affect flow patterns, and the changing chemistry of the effluent has the potential to impact downgradient groundwater. The ability to capture groundwater in various pit reclamation alternatives will affect the potential for additional impacts to groundwater in the permit area.

1.7.2.2.1.2 Risk of Violation of Groundwater Standards at Permit Boundary and Impacts to Beneficial Uses of the Jefferson River Alluvial Aquifer

If additional groundwater is impacted in the permit area from the open pit, then the potential to violate water quality standards at the permit boundary and impact beneficial uses in the Jefferson River alluvial aquifer must be evaluated.

1.7.2.2.2 Impacts to Surface Water Quality and Quantity

1.7.2.2.2.1 Impacts to Springs, Wetlands

Control of poor quality water both in and out of the pit is needed in order to prevent impacts to adjoining aquifers and possibly downgradient surface water.

One of the risks that have been identified is the potential development of seeps in areas outside of a backfilled pit. Natural ARD seeps, likely controlled by fractures in the mineralized bedrock, occur at the mine site. After mining, if the groundwater table rebounds to a static condition, fracture controlled flow to surface seeps could increase or develop again. Those reclamation alternatives that include backfill and/or that do not maintain the pit as a hydrologic sink are likely to have a greater potential for seep development, or for increased flow or metal loading at existing seeps, than those that do not include backfill. On the other hand, those alternatives that maintain the pit as a hydrologic sink could minimize the risk of seep development but would lead to flow reductions in local springs.

Although drainages within the mine boundary are ephemeral and there are no perennial streams within the mine boundary, surface water contamination from mine operations is potentially an issue at GSM. There are historic springs and seeps within the GSM permit area that could be impacted by mine or reclamation operations. Several of these springs or seeps (Bunkhouse, Rattlesnake, Stepan, and Stepan Original springs) produce acid drainage, much of which is from regional naturally mineralized areas and may not be impacted by GSM. Many seeps discharge from the pit highwall. The quantity and quality of water from the seeps varies seasonally. If pit water cannot be captured, it could influence surface water quality and quantity in the historic seeps and the small wetlands associated with them and/or at new discharge points.

1.7.2.2.2.2 Risk of Violation of Surface Water Standards and Impacts to Beneficial Uses of the Jefferson River and Slough

The 1997 Draft EIS, Section IV.B addressed impacts to seeps and springs that might be dewatered if the open pit is maintained as a hydrologic sink. The SEIS must analyze impacts to seeps and springs in backfill alternatives that may or may not allow the water table to rebound and discharge from the pit. The SEIS will analyze impacts to seeps and springs from all alternatives. The potential impacts of flow from the backfilled pit to the Jefferson River/Slough must also be analyzed.

1.7.2.2.3 Reclamation Plan Changes

1.7.2.2.3.1 Surface Disturbance

Cast blasting the upper highwall would occur under partial pit backfill alternatives around the pit area and would result in additional disturbance. Some waste rock and soil would have to be hauled to areas around the pit where access has been cut off. In order to access the top of the northwest highwall of the pit with equipment, additional acreage would be disturbed to construct haul roads and other features.

1.7.2.2.3.2 Hazards to Wildlife

Potential hazards to wildlife include birds landing in or ingesting poor quality water or acid salts in the pit, wildlife using water impacted by pit seepage, and wildlife falling off the highwall or pit benches.

1.7.2.2.3.3 Total Remaining Unrevegetated Acres

Impacts to vegetation caused by additional surface disturbance in each alternative as well as the amount of land left unrevegetated must also be evaluated.

1.7.2.3 Socioeconomic Issues

1.7.2.3.1 Safety

1.7.2.3.1.1 Risk to Workers (Reclamation and Construction)

Pit haul roads are steep and there are safety issues associated with operating haul trucks down pit haul roads to implement any backfill alternative. GSM's safety policy does not allow fully loaded haul trucks to travel down haul roads into the pit. Waste rock would have to be dumped from the top or trucks would only be partially loaded, resulting in a longer and more expensive project. The engineering and safety issues associated with the alternatives will be evaluated.

1.7.2.3.1.2 Risk to Workers (Long-Term Maintenance)

Safety and security of personnel and equipment that are required to be in the pit for maintenance of the dewatering system need to be addressed for alternatives that leave the pit open.

In some alternatives, the pit would be maintained in approximately the same configuration left by mining. In these cases, the pit has cliff-like configurations that could be hazardous. Stability of the highwall could deteriorate over time, producing raveling and sloughing. Some limited instability could also be associated with the backfill options as sloughing could occur along the recontoured pit highwall as the result of chemical weathering, freeze-thaw disturbance, and the buildup of groundwater in localized areas.

1.7.2.3.1.3 Risk to Public Safety

Under all open pit options, access restrictions on general public use would need to be maintained.

1.7.2.3.2 Mining Employment

1.7.2.3.2.1 Potential Employment from Mining Stage 5B

GSM has indicated that if a partial pit backfill alternative is selected, the decision to continue mining Stage 5B could be adversely affected. The number of jobs impacted with or without mining Stage 5B needs to be analyzed for backfill alternatives. Some alternatives may preserve the potential for future mining and possibly provide employment associated with continued mineral exploration.

1.7.2.3.3 Reclamation Employment

1.7.2.3.3.1 Reclamation Employment Opportunities

A certain number of jobs with or without mining Stage 5B will be created or maintained during the reclamation construction period. The amount of employment will depend on the alternative chosen. In general, alternatives with higher backfill requirements will provide more short-term socioeconomic benefit inside the county. For alternatives requiring more long-term monitoring and management, a small number of jobs will be sustained indefinitely.

1.7.2.3.4 Revenue from Taxes

1.7.2.3.4.1 Potential Tax Revenues from Mining Stage 5B

As long as the mining company or a successor controls the property, the water treatment plant and other property will remain on the county tax base. Under some alternatives, continued revenue from taxes due to mining would be generated. Under a partial pit backfill alternative, there is a possibility that these taxes would not be accrued if Stage 5B did not proceed to completion.

1.7.2.3.4.2 Potential Tax Revenues from Pit Backfill

Regardless of whether Stage 5B is completed, backfilling will produce short-term jobs and revenues. The impacts of backfilling on revenues will be addressed in each alternative.

1.7.2.3.5 Mineral Reserves and Resources

1.7.2.3.5.1 Access to Future Mineral Reserves/Resources

GSM contends that precious metal mineralization extends beyond the planned limits of the open pit floor and highwall. GSM also contends that if these resources are buried due to backfilling requirements, the cost of recovering minerals in the future may be so high that the resource is completely lost. Future access to minerals for each alternative needs to be evaluated.

1.7.2.3.6 Land Use After Mining

1.7.2.3.6.1 Suitability of Land Use After Mining

The potential for each reclamation alternative to achieve the land use after mining will be evaluated.

1.7.2.3.7 Aesthetics

1.7.2.3.7.1 Visual Contrast with Adjacent Lands

The alternatives in the SEIS are similar to those evaluated in the 1997 Draft EIS. The amount of visual contrast between reclaimed lands and adjacent undisturbed lands must be evaluated for each alternative.

1.7.2.3.8 Potential Future Burden

1.7.2.3.8.1 Potential Future Burden on Society

Closed mining operations with long-term management requirements represent a potential liability on society. Bonds are posted to address that risk. The future burden on society in each alternative must be evaluated.

1.7.2.3.8.2 Potential for Future Liabilities for GSM

For all alternatives, it is anticipated that pit water treatment would be required indefinitely. GSM has a water treatment plan and has posted bond with DEQ for long-term water treatment. Facilities used to collect, treat, release and monitor surface water and groundwater will need to be maintained, upgraded, rebuilt and/or replaced. Volumes of water needing treatment vary with each alternative.

Some alternatives may rely on mixing and partial attenuation of impacted water to produce a less degraded water chemistry. This could limit long-term management requirements, but may in turn increase risk and liability for the company.

Long-term water treatment represents the site management that the company will control. This represents a liability to the company. Alternatives that do not achieve complete control of pit water increase the liability for GSM or some other future party.

1.7.2.4 Project Economics Issues

1.7.2.4.1 Reclamation Costs

Some level of backfilling could eliminate any reasonable likelihood of realizing a positive return on investment for GSM. Reclamation costs must be evaluated as an impact to GSM.

1.7.3 Issues Considered but Not Studied in Detail

Issues not studied in detail and the rationale for their exclusion are discussed below.

1.7.3.1 Wetlands

Wetland issues were addressed in the 1997 Draft EIS, Chapter IV, Section IV.D. Approximately 56 to 58 more acres would be disturbed under the partial pit backfill alternatives to build haul roads and to cast blast the upper highwall. No new wetlands would be disturbed in these acres.

1.7.3.2 Wildlife and Fisheries

Wildlife and fisheries issues associated with the permit area were evaluated in the 1997 Draft EIS, Chapter IV, Section IV.E. No new impacts to wildlife or fisheries have been identified in the 56 to 58 acres that would be disturbed under the partial pit backfill alternatives in addition to those disclosed in previous reviews. The potential for each reclamation alternative to achieve the wildlife habitat land use after mining is evaluated in the SEIS in Section 4.3 Environmental Issues.

1.7.3.3 Threatened, Endangered, and Candidate Species

Issues associated with threatened, endangered, and candidate species were addressed in the 1997 Draft EIS, Chapter IV, Section IV.F. Approximately 56 to 58 more acres would be disturbed under the partial pit backfill alternatives to build haul roads, cast blast the upper highwall, and install dewatering and monitoring wells and access roads. No new impacts from the disturbance would affect threatened, endangered, or candidate species or their habitats. The agencies concluded no additional evaluation was required.

1.7.3.4 Air Quality

Fugitive dust emissions from mine traffic are expected for partial pit backfill alternatives due to the large amount of backfill anticipated to be transported to the pit. In addition, mine vehicle exhaust emissions are also expected. Potential changes in ambient air quality (Montana and National Ambient Air Quality Standards) and impacts on visibility could occur.

Air quality impacts were evaluated in the 1997 Draft EIS, Chapter IV, Section IV.G. Air quality from hauling waste rock has not been affected beyond the permit boundary during operations. The amount of traffic generating dust and emissions would be similar to historical mine operations. Therefore, the agencies have concluded that no impacts above those analyzed in previous environmental reviews would occur.

1.7.3.5 Aesthetic Resources

1.7.3.5.1 Noise

Noise impacts were evaluated in the 1997 Draft EIS, Chapter IV, Section IV.I. Noise impacts have been minimal beyond the permit boundary during operations. The amount of mine activity generating noise would be similar to mine operations historically. The agencies have concluded that no impacts above those analyzed in previous environmental reviews would occur.

1.7.3.6 Solid and Hazardous Materials and Wastes

Solid and hazardous materials and wastes were addressed in the 1997 Draft EIS, Chapter IV, Section IV.K. No additional materials or waste have been identified that would be generated under the alternatives in addition to impacts disclosed in previous reviews.

1.7.3.7 Cultural Resources

Cultural resource issues were addressed in the 1997 Draft EIS, Chapter IV, Section IV.L. Cultural resources consist of prehistoric and historic archaeological deposits; structures of historic or architectural importance; and traditional ceremonial, ethnographic, and burial sites. Cultural resources are nonrenewable resources, which are afforded protection by federal, state, and local laws, ordinances, and guidelines.

Several previous archaeological surveys have been conducted in the vicinity (Table 1-2). Reports detailing the results of intensive archaeological evaluations conducted in the GSM area are on file at the BLM Butte Field Office and at the SHPO office in Helena. The only cultural resource that might be affected by pit reclamation is a historic cabin near the north highwall. Should an alternative involving cast blasting be selected, there would be an adverse impact to this historic property, which would require mitigation.

1.7.3.8 Paleontological Resources

Paleontological resource issues were addressed in the 1997 Draft EIS, Chapter IV, Section IV.A. No additional impacts to paleontological resources have been identified in the 56 to 58 acres that would be disturbed under the partial pit backfill alternatives in addition to impacts disclosed in previous reviews. The chances of finding a paleontological resource in the pit area geology are minimal.

1.7.3.9 Native American Concerns

Native American concerns were addressed in the 1997 Draft EIS, Chapter IV, Section IV.M. The 56 to 58 acres of disturbance under the partial pit backfill alternatives would not impact any Native American traditional use sites. No new Native American concerns have been identified in new disturbance areas under the partial pit backfill alternatives. No additional evaluation was required.

1.7.3.10 Areas of Critical Environmental Concern

No areas of critical environmental concern would be affected by any of the alternatives.

1.7.3.11 Prime or Unique Farmlands

No prime or unique farmlands would be affected by any of the alternatives.

1.7.3.12 Floodplains

No floodplains would be affected by any of the alternatives.

1.7.3.13 Wild and Scenic Rivers

No wild or scenic rivers would be affected by any of the alternatives.

1.7.3.14 Wilderness

No wilderness areas would be affected by any of the alternatives.

1.7.3.15 Environmental Justice

As required by Executive Order 12898, Federal *Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* the alternatives were evaluated for issues relating to the social, cultural, and economic well being, and health of minorities and low-income groups. None of these environmental justice issues was identified. The socioeconomic impacts of any of the alternatives would not affect minority or low-income groups disproportionately.

1.7.3.16 Invasive Non-Native Species

Non-native noxious weed species were evaluated in the 1997 Draft EIS, Chapter IV, Section IV.D. The county noxious weed list designates noxious weeds for Montana under the County Weed Control Act 7-22-2101(5), MCA. Seven species on this list were identified in the GSM study area during previous inventories: *Cirsium arvense* (Canada thistle), *Cardaria draba* (whitetop or hoarycress), *Centaurea maculosa* (spotted knapweed), *Euphorbia esula* (leafy spurge), *Linaria dalmatica* (dalmatian toadflax), *Hyocyamus niger* (henbane), and *Cynoglossum officinale* (hounds tongue). In general, these species have been confined to areas of recent and historic disturbance, e.g., roadsides, abandoned roads and homesteads, and drainage bottoms affected by fluvial events and livestock impacts.

Noxious weeds have been actively controlled by GSM since 1984 on areas within the mine permit boundary and on nearby property owned by the mine (GSM 1990 to 2003 annual reports). A weed control plan was submitted to the Jefferson County weed control board in 1993. The primary concern has been spotted knapweed because of its widespread occurrence and the potential for infestation in areas of disturbed, dry rocky soils. Dalmatian toadflax has also recently become a concern. The small areas infested with whitetop are generally limited to ephemeral drainage bottoms and near the Jefferson Slough. Leafy spurge is very limited, also occurring primarily near the Jefferson Slough.

The control of noxious weeds is an important element of successful final reclamation. GSM will continue to monitor and control harmful weeds during operations and closure. The methods of monitoring and controlling invasive non-native species of vegetation would not vary by alternative. The 56 to 58 acres of new disturbance under the partial pit backfill alternatives would increase the area needing weed control. No additional evaluation was required.

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Chapter 2

Description of Alternatives

2.1 INTRODUCTION

GSM operates an open pit gold mine and mineral processing facility at the south end of Bull Mountain near Whitehall, Montana. Bull Mountain forms a north-south trending topographic divide ranging in elevation from approximately 5,000 to 6,500 feet in the mine area. The open pit lies just east of the topographic divide and currently occupies an area with 218 acres of total disturbance. This will not increase in size through Stage 5B.

As described in Section 1.4.3, the mine and facilities would normally be reclaimed under reclamation plans that have been approved by DEQ and BLM. However, portions of the statute relied on to select the method of pit closure in the 1998 ROD was ruled unconstitutional by the District Court. In its June 2002 judgment, the District Court ordered DEQ to begin implementation of a partial pit backfill reclamation plan in accordance with the procedures set forth in MMRA. To comply with the court order, and because pit designs have changed and new technical data are available to reevaluate potential environmental impacts of closure by partial pit backfilling, DEQ and BLM have determined that an SEIS is required.

This chapter includes:

- A description of the mine plan and modifications that affect the ultimate configuration of the open pit;
- The process used to formulate the pit closure alternatives evaluated in this SEIS;
- Descriptions of the alternatives that have been considered;
- A summary of the reclamation impacts projected for each of the alternatives considered; and,
- The agencies' Preferred Alternative.

A range of alternatives was developed as a result of the scoping process. All reasonable alternatives were explored and objectively evaluated. Although some of the alternatives were eliminated from detailed study, descriptions of all alternatives are included in this chapter. The Partial Backfill Alternative described in the 1998 Final EIS and subsequently updated to reflect current conditions and modifications (GSM, 2002) is the Proposed Action Alternative. The No Pit Pond Alternative described in the 1998 Final EIS and the 1998 ROD serves as the No Action Alternative. Five additional alternatives or variations of these alternatives were studied in this SEIS. Two of the five alternatives were evaluated in detail.

GSM was permitted for 2,964 acres of disturbance (1997 Draft EIS, Table II-22)(GSM 2003 annual report). GSM's currently approved area for disturbance is 3,002.25 acres. GSM is currently bonded for 2,619.55 acres of disturbance. GSM's permit area is 6,125 acres.

Table 2-1 compares the permitted disturbances at GSM with the proposed disturbances at the end of Stage 5B mining (GSM 2003 annual report). GSM's current actual disturbance is 2,234 acres. In 2004 in preparation for a complete recalculation of the reclamation bond, GSM reinventoried all disturbance and reclamation at the site (GSM 2003 annual report). This was accomplished using the latest aerial photography and site reconnaissance. A new disturbance map was developed and was used to prepare the figures in the SEIS. The numbers reported in Table 2-1 are based on the latest acreage determination and are considered the most accurate. Because these numbers were developed from new site maps and surveys, the numbers do not match the table in the GSM 2002 annual report or the 1997 Draft EIS, Table II-22. The disturbance categories were modified to better reflect actual disturbance. Some acreages were moved from one disturbance category to another.

GSM has completed 1,054 acres of reclamation within the disturbance boundary as of December 31, 2003. Table 2-1 details the completed reclamation.

Table 2 - 1 Summary of GSM's Permitted Disturbance and Reclaimed Areas

Disturbance Category	Disturbance at End of Stage 5B (Acres)	Reclaimed as of December 31, 2003 (Acres)	1997 Draft EIS Permitted Disturbance (Acres)
West Waste Rock Dump Complex	507	507	616
East Waste Rock Dump Complex	438	152	670
Open Pit Area	286	0	336
Open Pit[1]	218	7	254
Buttress Dump	46	51	266
Facilities	90	4	187
Tailings Impoundments	473	250	865
Other	394	83	94
TOTAL	**2,234**	**1,054**	**2,964**

GSM 2003 annual report and 1997 Draft EIS Table II-22.

---

[1] Included in Open Pit Area acreage

2.2 MINE PLANNING

2.2.1 Pit Development and Waste Rock Dump Complexes

Mining at GSM is accomplished with conventional open-pit methods that consist of drilling, blasting, loading, and hauling. Waste rock has been extracted and hauled to dump complexes located at the east, west, and south sides of the pit. All waste rock from current mining activities is placed in the East Waste Rock Dump Complex. The bottom of the pit is currently at an elevation of 4,650 feet, 700 feet below the lowest point on the eastern rim of the pit. Figure 1-2 shows the entire mine and facilities area.

Since mining began in 1982, pit development has occurred in stages, which have progressively deepened and expanded the pit. Pit Stages 1 through 5A have been completed. Development of the Stage 5B Pit to the 4,650-foot elevation has been approved by the agencies. In September 2003, GSM decided to begin mining Stage 5B and is now proposing an ultimate pit bottom elevation of 4,525 feet. The agencies will evaluate this change of pit depth in this SEIS. Figure 2-1 shows the ultimate pit configuration upon completion of the Stage 5B Pit. The mill was shut down in December 2003. Stripping waste rock for Stage 5B will continue for 16 to 18 months. Then mining ore and milling operations will start up again.

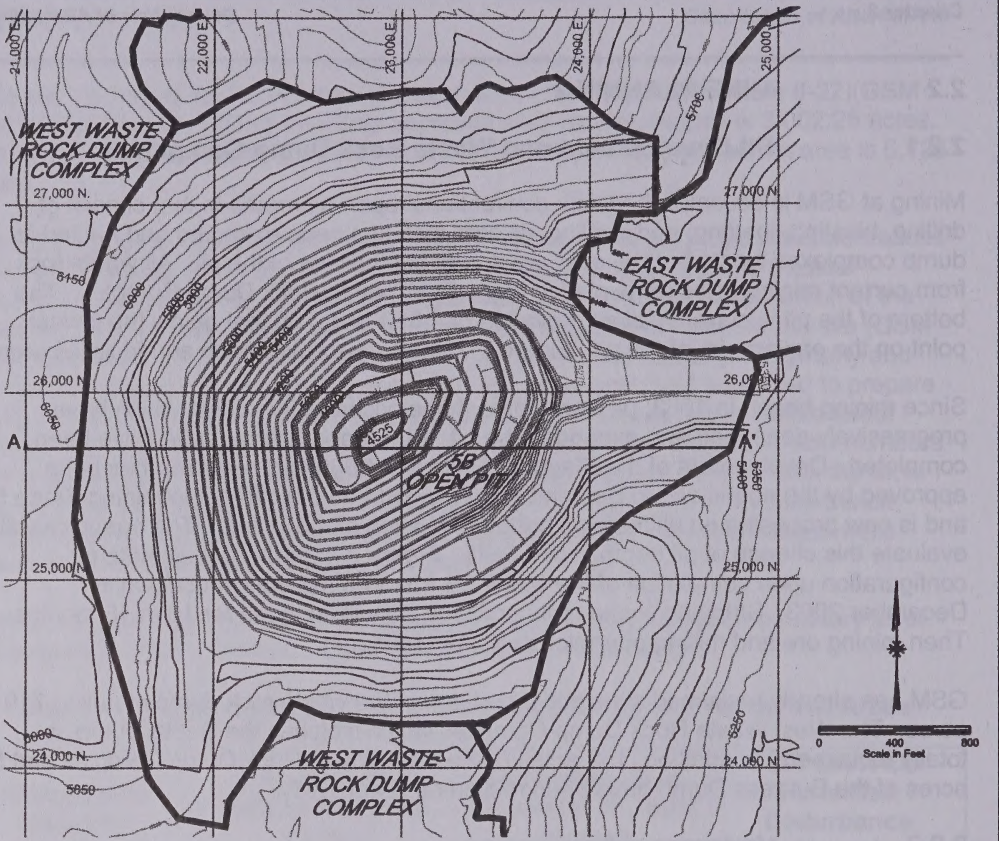
GSM has already reclaimed substantial portions of the waste rock dumps totaling 710 acres. The West Waste Rock Dump Complex, which includes the South Dump, is totally reclaimed. In addition, 152 acres of the East Waste Rock Dump Complex and 51 acres of the Buttress Dump have been reclaimed (Table 2-1).

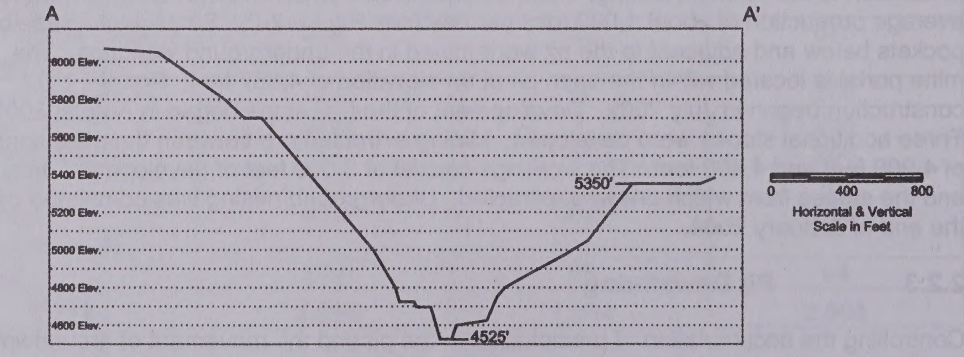
2.2.2 Underground Operation

In addition to the open pit mining, GSM has operated a small underground mine with an average production of about 1,000 tons per day (see Figure 2-2). Small, high-grade ore pockets below and adjacent to the pit were mined in the underground workings. The mine portal is located within the open pit at an elevation of 4,857 feet. Portal construction began in July 2002. Development of the first stope began in August 2002. Three additional stopes were developed. Mining extracted ore between the elevations of 4,900 feet and 4,400 feet. The workings consist of 3,000 feet of development drifts and the stopes from which ore was extracted. Underground mining was completed by the end of January 2004.

2.2.3 Pit Dewatering

Controlling the accumulation of precipitation in the pit and the movement of groundwater through the pit highwall is an important aspect of the pit development plan. Mine dewatering is conducted at GSM to dewater the ore and waste rock actively being mined, to keep the pit floor and underground workings dry, and to release pore pressures in the open pit highwalls. Dewatering operations are monitored by recording pumping rates and collecting water samples for chemical analyses.


21,000 E.
22,000 E.
23,000 E.
24,000 E.
25,000 E.
WEST WASTE ROCK DUMP COMPLEX
EAST WASTE ROCK DUMP COMPLEX
5B OPEN PIT
27,000 N.
26,000 N.
25,000 N.
24,000 N.
A
A'
4525
5700
6150
6050
6000
5900
5850
5800
5600
5400
5350
5250
5200
5000
4800
0
400
800
Scale in Feet


A
A'
6000 Elev.
5800 Elev.
5600 Elev.
5400 Elev.
5200 Elev.
5000 Elev.
4800 Elev.
4600 Elev.
5350'
4525'
0
400
800
Horizontal & Vertical
Scale in Feet

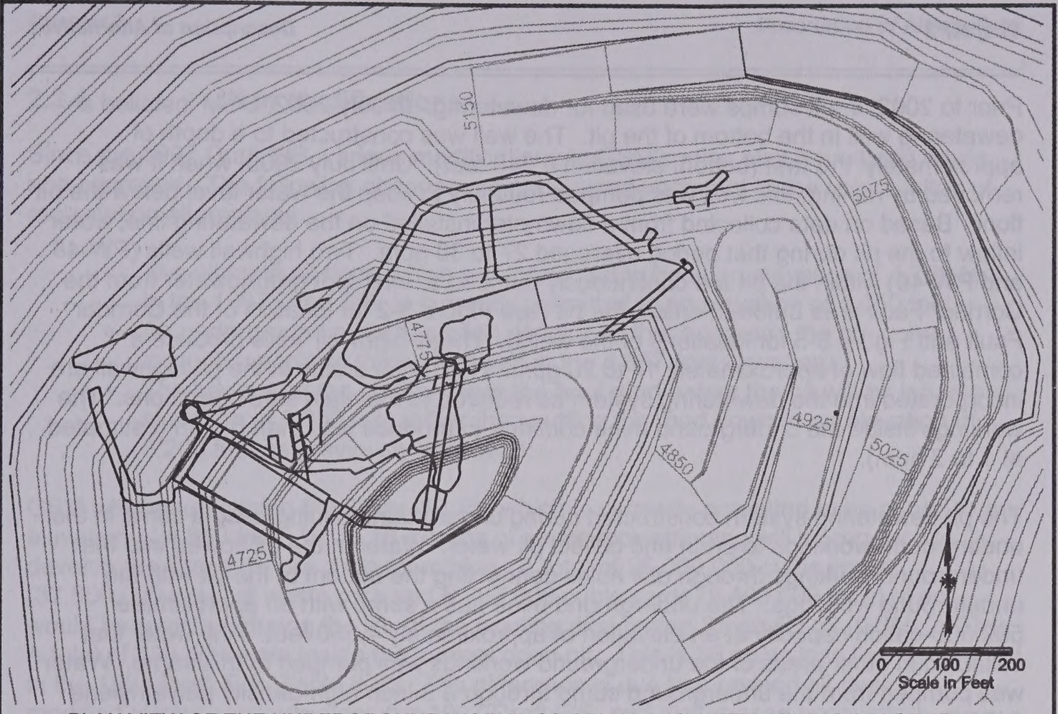
Ultimate Pit Floor Elevation = 4525 Feet

All Alternatives

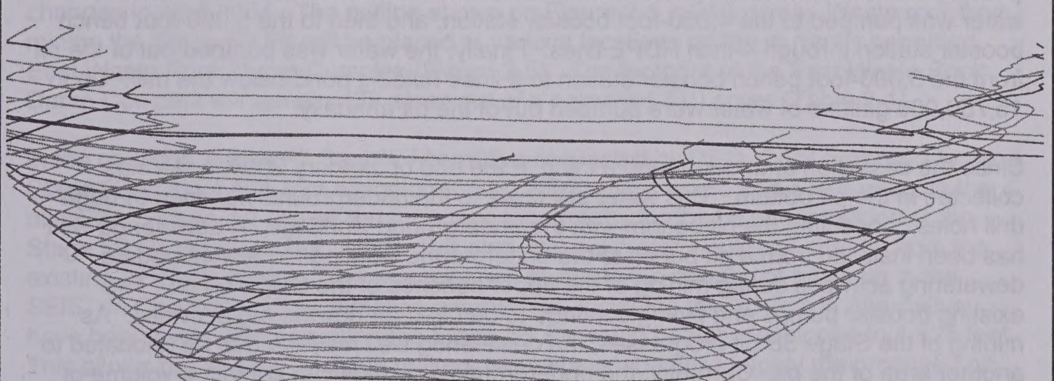
STAGE 5B
PIT EXPANSION
MINE PLAN

Figure 2-1 expand-5b.dwg

FIGURE 2-1


5150
5075
4775
4925
5025
4850
4725
0
100
200
Scale in Feet

PLAN VIEW OF THE UNDERGROUND WORKINGS REMAINING AFTER MINING STAGE 5B



3-D VIEW OF UNDERGROUND WORKINGS AFTER MINING STAGE 5B

Note:
Major portion of underground workings will be mined out during Stage 5B including the 4857 Portal.

Figure 2-2-rev4-04-underground.dwg

RELATION OF UNDERGROUND WORKINGS TO FINAL STAGE 5B PIT

FIGURE 2-2

Prior to 2002, in-pit sumps were used for dewatering. In July 2002, GSM installed a dewatering well in the bottom of the pit. The well was constructed to a depth of approximately 118 feet (bottom elevation 4,748 feet). Until July 2003, when it was removed by mining, this well was pumped routinely to keep the water level below the pit floor. Based on data collected from a flowmeter installed on the dewatering line, water inflow to the pit during that period averaged 27 to 30 gpm. Two highwall wells (PW-48 and PW-49) within the pit are continuously pumped to intercept groundwater from the Corridor Fault area before it enters the pit (see Figure 3-2 for location of the Corridor Fault and Figure 3-5 for locations of the wells). These highwall wells produce a combined flow of approximately 17 to 20 gpm. Horizontal drains in the pit highwall are incorporated into the dewatering system as required to maintain safe operations. The workings inside the underground mine continue to produce less than 5 gpm (estimated at 1 to 2 gpm).

The pit dewatering system constructed during underground mining used a sump in the underground workings to drain and collect pit water. Water in the pit flowed into the underground workings through drill holes connecting the bottom of the pit with the underground workings. The underground mine has a sump with an approximate 500,000-gallon capacity at an elevation of approximately 4,650 feet. Any water that collected in other areas of the underground workings was pumped to this sump. Water was pumped from the underground sump through a 3-inch high-density polyethylene (HDPE) line to the 4,700-foot booster station. From the 4,700-foot booster station, water was pumped to the 4,850-foot booster station, and then to the 5,000-foot bench booster station through 4-inch HDPE lines. Finally, the water was pumped out of the pit from the 5,000-foot bench booster station to a lined holding pond below the mill. Up to 15,750,000 gallons of water were pumped out of the pit annually.

Since the cessation of underground mining at the end of January 2004, water has collected in the pit bottom. This water still flows to the underground workings through drill holes connecting the pit bottom with the underground workings. A dewatering well has been installed from a pit bench to the underground workings to accommodate dewatering activities during mining of the upper benches of the Stage 5B pit. The existing booster pumps and piping continue to be used for dewatering activities. As mining of the Stage 5B pit progresses, the dewatering well may need to be relocated to another area of the pit. Currently, the underground workings can contain a volume of 20 million gallons of water before the water table reaches the pit bottom at the 4,650-foot elevation.

Water removed from the pit is either sprayed over blasted rock to control dust or is pumped to the lined holding pond below the mill and then to the water treatment facility in the mill. The water from the highwall dewatering wells is mixed with treatment plant discharge and directed to the land application disposal (LAD) infiltration basin, to the lined pond below the mill for treatment at the water treatment plant, or to Tailings Impoundment No. 2 for reuse as process water.

2.2.4 Plan Modifications

Since the 1997 Draft EIS, various modifications to GSM's mine plan have been made and approved. The following changes are considered important to the reevaluation of reclamation alternatives:

- The ultimate pit floor, which was projected to be at an elevation of 4,700 feet in the 1997 Draft EIS, is currently permitted to an elevation of 4,650 feet.
- An underground mine has been developed that accessed the ore zone through a portal in the pit highwall at the 4,857-foot elevation.
- The key cut on the pit rim where the haul road enters the pit will be left at an elevation of 5,350 feet rather than cutting the road down to an elevation of 5,200 feet as previously approved.

GSM has begun mining the Stage 5B Pit, which is currently permitted to be mined to an elevation of 4,650 feet. Up to 18 months of waste rock stripping will be required to develop the Stage 5B ore zone for mining. A total of 25,000,000 cubic yards (37,500,000 tons) of waste rock and 6,267,000 cubic yards (9,400,000 tons) of ore would be removed during the life of the existing designated Stage 5B pit (GSM, 2003d). A total of 218 acres are inside the current open pit. This is 36 acres less than presented in the 1997 Draft EIS, Table II-22. The difference is due to a revised pit design, modified mining methods since the 1997 Draft EIS, and disturbance accounting changes in April 2004. The outline shown on Figure 2-1 is 218 acres. Waste rock from mining the Stage 5B Pit will be placed at various locations on the currently permitted East Waste Rock Dump Complex (Figure 2-5). The footprint of the East Waste Rock Dump Complex will remain 438 acres out of a permitted 670 acres (Table 2-1).

In the modified Partial Pit Backfill Alternative requested by DEQ, GSM proposed to mine Stage 5B to the 4,525-foot elevation (GSM, 2002). This would add 4 to 5 years to the mine life. Figure 2-1 shows the proposed topography for the pit at completion of the Stage 5B Pit development. Under this plan, the perimeter would not change from the existing pit configuration. The agencies will evaluate the change of pit depth in the SEIS. In Chapter 4, all reclamation alternatives, including the No Action Alternative, have been evaluated assuming the Stage 5B Pit would be fully developed to 4,525 feet. This allows the agency decision makers to evaluate whether to apply the proposed pit changes to any of the alternatives, including the No Action Alternative.

2.3 DEVELOPMENT OF ALTERNATIVES

The action under review is reclamation of the open pit. This section provides a brief description of how the various reclamation alternatives were developed for evaluation in this document. Because several of the alternatives have a long history of environmental review and litigation associated with them, historical background has been included in Section 1.4.3.

2.3.1 1998 EIS Record of Decision

The ROD for the 1998 Final EIS selected the No Pit Pond Alternative. This alternative required the bottom 100 feet of the pit (from an elevation of 4,700 feet to 4,800 feet) to be backfilled with unspecified waste rock from the East Waste Rock Dump Complex. The backfill would be used as an underground sump to prevent a pond from forming in the pit. A well in the backfill would be used for pit dewatering coupled with water treatment. The top of the backfill would provide a working surface of 7.4 acres where personnel could install and maintain the two-well dewatering system. Worker and dewatering system protection would be provided by building one or more berms around the perimeter of the working area to trap rocks that might ravel from the highwall.

The major focus of the No Pit Pond Alternative was the avoidance of groundwater degradation by pumping water out of the backfill to maintain the groundwater level near 4,700 feet. Another objective was to prevent exposure of wildlife to contaminated water after closure. Maintaining the pit as a hydrologic sink and capturing all pit water inflows would achieve these goals. Slopes less than 2H:1V and major pit roads and the pit bottom would have been covered with 2 feet of oxidized waste rock, 2 feet of soil, and revegetated. Twenty-six out of the 254 pit acres would have been revegetated. The rest of the pit was to be reclaimed as highwalls and talus slopes. In the 1998 Final EIS, DEQ and BLM concluded that the No Pit Pond Alternative would substantially achieve those objectives. It is the currently approved reclamation plan for the pit. This plan has been modified to reflect current conditions at the mine and constitutes the No Action Alternative that has been reevaluated in this SEIS.

2.3.2 1997 Draft EIS Partial Backfill Alternative

As described in Section 1.4.3, in a June 2002 judgment, the District Court ordered DEQ to begin implementation of the partial pit backfill reclamation plan, which had been evaluated in the 1997 Draft EIS, in accordance with MMRA. The 1997 Draft EIS Partial Backfill Alternative projected an ultimate pit floor elevation of 4,700 feet. As conceptually described, the Partial Backfill Alternative would require the GSM pit to be backfilled. The ultimate pit would be backfilled to the low point on the rim of 5,200 feet. The upper pit highwall would be reclaimed to 2H:1V slopes by hauling, end dumping, and dozing waste rock. Backfilling would have consisted of two activities:

- Hauling, end dumping, and dozing 34,700,000 to 36,700,000 cubic yards (52,000,000 to 55,000,000 tons) of waste rock material from the East Waste Rock Dump Complex to backfill the pit and cover the lower highwall; and,
- Hauling, end dumping, and dozing approximately 21,000,000 to 22,000,000 cubic yards (31,000,000 to 33,000,000 tons) of waste rock material from the West Waste Rock Dump Complex to complete covering of the highwall.

The backfilled area would be graded to a free-draining surface. All acid producing rock within the pit would be covered with two feet of oxidized waste rock. Then that surface would be covered with two feet of soil. The entire pit area of 254 acres would be revegetated.

Pit dewatering coupled with water treatment would be required. The wells would be installed through the backfill in order to maintain the pit as a hydrologic sink. However, the agencies believe technical feasibility and potential effectiveness of these measures were not evaluated adequately in the 1997 Draft EIS.

The Partial Pit Backfill With In-Pit Collection Alternative described in this SEIS is presented as the Proposed Action to comply with the District Court's 2002 order. Under this alternative, some changes to the 1997 Draft EIS Partial Backfill Alternative are being evaluated:

- The elevation of the floor of the pit would be changed from 4,700 feet to 4,525 feet;
- Waste rock would be hauled from the East Waste Rock Dump Complex. No backfill would be obtained from the reclaimed West Waste Rock Dump Complex;
- The pit would be backfilled to a minimum elevation of 5,350 feet, which is the low point elevation on the eastern pit rim;
- Portions of the upper pit highwall would be cast blasted and dozed to achieve the 2H:1V slopes, increasing the total pit disturbance area by 56 acres (8.9 acres south of pit, 42.2 acres north and west of pit, and 4.9 acres of roads around the top rim of the pit) from 218 acres to 274 acres (Figure 2-4); and,
- The reclamation cover would be a 3-foot-thick layer of soil with more than 45 percent rock fragments amended in the surface, instead of two feet of oxidized waste rock covered with two feet of soil. This is the currently approved reclamation cover plan for all waste rock dump complexes at GSM (DEQ/BLM, 2002 and 2003)

2.3.3 Determination of Range of Alternatives

DEQ and BLM used comments received during the scoping process described in Section 1.7.1 and previous environmental documents prepared on the mine to determine the range of alternatives. To assist the agencies in determining the range of alternatives to be evaluated in this SEIS, DEQ and BLM initiated an MAA process in May 2003. BLM, DEQ, EPA, GSM, and the environmental groups that are plaintiffs in the District Court action each sent two technical personnel to form a technical working group (TWG) to produce and evaluate alternatives using the MAA process.

As the process evolved, the TWG found deficiencies in the alternatives and modified them to produce refined alternatives. Between meetings, proposed modifications were evaluated by various experts and the TWG was supplied with these supplemental analyses. During this process, public comment from a scoping meeting conducted in Whitehall was incorporated into the process. A local rancher also attended the fourth MAA meeting.

During the evaluation, the TWG identified and evaluated the following seven alternatives:

1. No Pit Pond (No Action) (includes in-pit water collection);
2. Partial Pit Backfill With In-Pit Collection (Proposed Action);
3. Partial Pit Backfill Without Collection;
4. Partial Pit Backfill With Downgradient Collection;
5. Partial Pit Backfill With Amendment;
6. Underground Sump (with underground water collection sump); and,
7. Pit Pond (with pump and treatment).

The agencies have identified 13 technical issues, 7 environmental issues, 12 socioeconomic issues, and 1 project economics issue as having importance for pit reclamation (Table 1-4). These are defined in Section 1.7.2 with additional explanation found in the Technical Memorandum describing the MAA process (Robertson GeoConsultants, 2003).

DEQ and BLM reviewed the results of the MAA process during preparation of this SEIS. The agencies determined that the range of alternatives identified satisfies the requirements of MEPA and NEPA and the District Court's 2002 order. Selection of the Preferred Alternative was based on data, studies, and analysis pertaining to these alternatives, which are described in Chapter 4, and the mandates of the laws, rules, and regulations administered by the agencies.

2.4 ALTERNATIVES CONSIDERED FOR DETAILED STUDY

2.4.1 Introduction

Seven alternatives were developed and evaluated. Three of the alternatives were dismissed from detailed consideration in the SEIS due to environmental or technical concerns (see Section 2.5). Four alternatives were studied in detail. These include:

- The No Pit Pond (No Action) Alternative, presented in the 1997 Draft EIS and selected as the Preferred Alternative in the 1998 ROD, as modified per current mine conditions (GSM, 2002);
- The Partial Pit Backfill With In-Pit Collection Alternative (Proposed Action), presented in the 1997 Draft EIS as the Partial Backfill Alternative as modified by GSM (GSM, 2002);
- The Partial Pit Backfill With Downgradient Collection Alternative developed to address the concerns with in-pit pumping associated with the Partial Pit Backfill With In-Pit Collection Alternative; and,
- The Underground Sump Alternative developed to address concerns with in-pit pumping and the potential burial of mineral resources and reserves associated with the partial pit backfill alternatives.

2.4.2 No Pit Pond Alternative (No Action)

As described in the 1998 ROD, DEQ and BLM selected the No Pit Pond Alternative in order to maintain the pit as a hydrologic sink, preventing any contaminated water from leaving the pit and moving into the regional groundwater system. Because the agencies also wanted to prevent a pit pond from forming, the bottom 100 feet of the pit would be backfilled with unspecified waste rock from the East Waste Rock Dump Complex to create a backfill sump. The backfill would serve as a flat working surface on which to station two dewatering wells and other components of a collection system. The dewatering system would collect water in the sump and pump it to a permanent water treatment plant. By maintaining the groundwater level as low as possible in the backfill, no water would be allowed to pond in the pit bottom. Protection for the pumping facilities and workers would be provided by building one or more berms around the perimeter of the 7.4-acre working area to trap rocks that might fall from the pit highwall. A 4-foot cover system would be placed over the backfill.

Since the ROD was issued in June 1998, changes have been made to the planned pit configuration to enhance safety, improve the ore to waste ratio, and target ore zones. Modifications common to all alternatives are outlined in Section 2.2.4. Additional planning and investigation to implement this pit closure plan has also continued. The changes affecting the No Pit Pond Alternative are as follows:

- The pit would be backfilled from an ultimate pit bottom elevation of 4,525 feet to an elevation of 4,625 feet instead of 4,700 feet to 4,800 feet;
- The flat working surface on top of the pit backfill would decrease to 1.3 acres from the previously planned 7.4 acres;
- Crusher reject waste rock materials would be used for the sump backfill;
- The cover system would consist of 3 feet of soil instead of 2 feet of oxide rock covered with 2 feet of soil; and,
- During reclamation, accessible pit roads, benches, and other areas within the pit would be resoiled and revegetated (consisting of 1 acre of pit floor working surface, 7 acres already reclaimed, and 52 acres of miscellaneous and pit roads), leaving approximately 158 acres (218 acres less 60 acres) of pit area unrevegetated. The area inside the perimeter of the pit would be 218 acres instead of 254 acres (see previous discussion in Section 2.2.4) projected in the 1997 Draft EIS (Table II-22).

2.4.2.1 Underground Mine Closure

Although underground mining ceased at the end of January 2004, the underground sump in the underground mine would not be closed until the end of mining because it would be used as part of a dewatering system for Stage 5B. Portions of the underground mine that break through into the pit or that might pose a hazard to workers in the pit would be backfilled. As of June 2004, no underground workings have been backfilled. The current mine plan for the 5B Pit includes mining a safe distance from the underground stopes, backfilling the stopes, and then mining through the stopes (S.

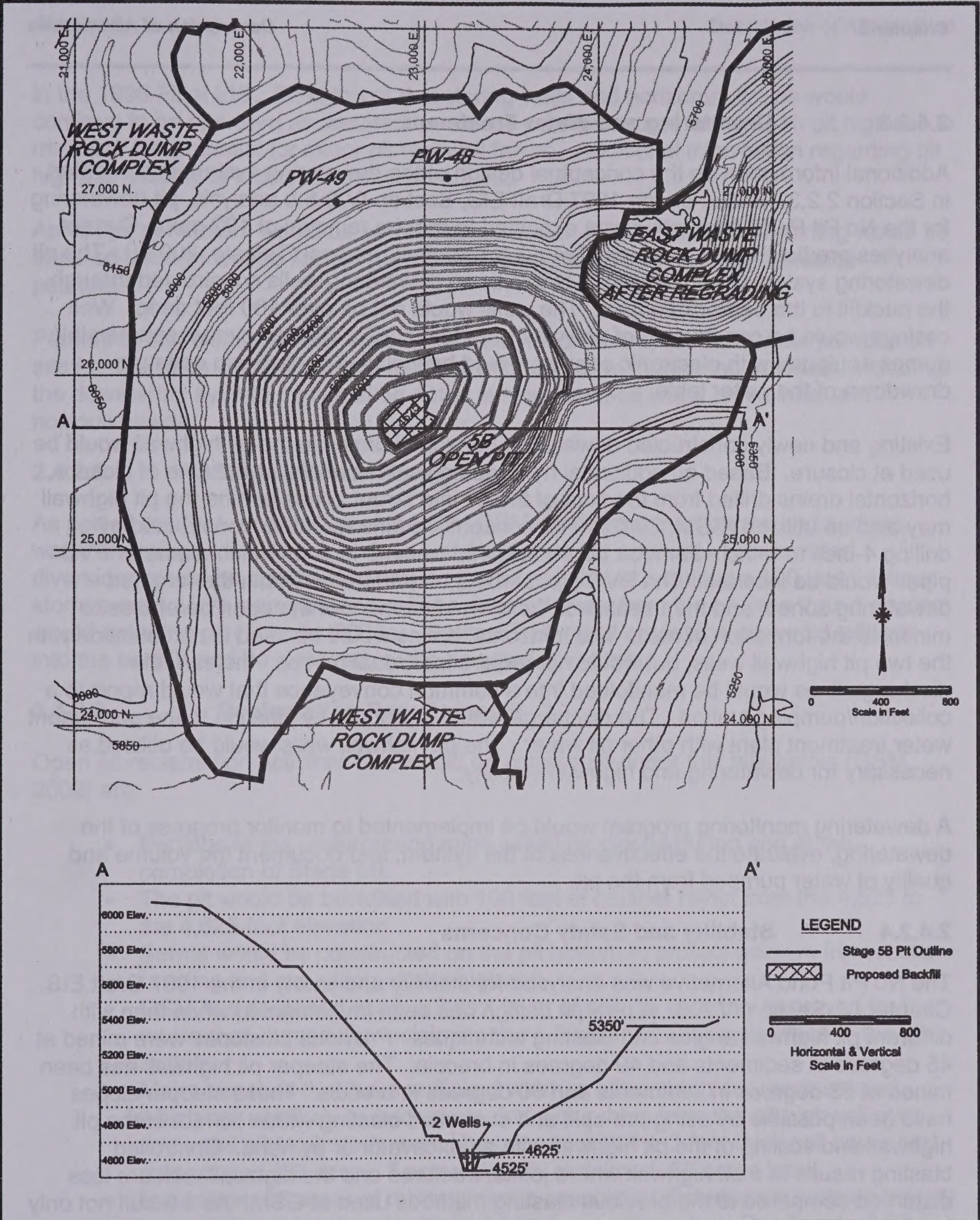
Dunlap, GSM, personal communication June 21, 2004). Because the underground workings have encountered less than 5 gpm of water, the water from the underground mine is not expected to alter the final water management system.

2.4.2.2 Stage 5B Pit Backfill Plan

The lower portion of the Stage 5B Pit would be backfilled with 100 feet of crusher reject waste rock to provide a flat working area of 1.3 acres on which to station dewatering wells and other collection equipment. A 3-foot-thick layer of soil would be placed as a cover over the backfill. Approximately 111,000 cubic yards (167,000 tons) of backfill and 6,400 cubic yards of soil would be required. This limited amount of backfill would provide a sump to absorb precipitation and pit groundwater, thereby preventing a pond from forming in the bottom of the pit. Figure 2-3 shows the final topography (plan view) of the proposed backfilled Stage 5B Pit, as well as a cross-section of this pit configuration after backfilling, and dewatering well locations.

Backfill material was identified as waste rock in the 1997 Draft EIS, Section II.B.6.b. There are two potential on-site sources of waste rock for the backfill (GSM, 2002). One source of material is stockpiled mixed waste rock that is stored for reclaiming waste rock disposal areas. Mixed waste rock consists of both sulfide and oxide waste rock. Another source is the crusher reject material. Due to the screening process, this material is fairly uniform in size and could provide a good material for sump construction. This is the material proposed for backfilling under this alternative.

The reclamation cover being considered in the various alternatives that use pit backfill is different than the approved cover that was described in the 1997 Draft EIS. The approved cover consists of 2 feet of oxide rock overlain by 2 feet of soil. The proposed modified cover consists of a 3-foot soil cover. This cover has been previously approved by the agencies for use on 2H:1V slopes on the East Waste Rock Dump Complex (DEQ and BLM, 2003).


21,000 E
22,000 E
23,000 E
24,000 E
25,000 E
WEST WASTE ROCK DUMP COMPLEX
PW-48
PW-49
27,000 N.
27,000 N
EAST WASTE ROCK DUMP COMPLEX AFTER REGRADING
5700
6150
6000
5850
5800
5600
5400
5250
26,000 N
6050
A
A'
5B OPEN PIT
5400
5350
25,000 N
25,000 N
6000
24,000 N.
24,000 N
5850
5250
WEST WASTE ROCK DUMP COMPLEX
0
400
800
Scale in Feet
A
A'
6000 Elev.
5800 Elev.
5600 Elev.
5400 Elev.
5200 Elev.
5000 Elev.
4800 Elev.
4600 Elev.
5350'
2 Wells
4625'
4525'
LEGEND
Stage 5B Pit Outline
Proposed Backfill
0
400
800
Horizontal & Vertical Scale in Feet

No Pit Pond Alternative
would have two dewatering wells
through the 100 feet of backfill
from the 4525 to 4625 elevation

No Pit Pond (No Action) Alternative

FINAL
NO PIT POND
CONFIGURATION

FIGURE 2-3

2.4.2.3 Dewatering and Water Treatment

Additional information on the conceptual design of the dewatering system is presented in Section 2.2.3. Based on the 1997 Draft EIS, Section IV.B.6.b analysis, pit dewatering for the No Pit Pond Alternative was expected to require removal of 102 gpm. Current analyses predict that 32 gpm would require perpetual removal (Telesto, 2003a). The pit dewatering system would consist of two to three dewatering wells constructed through the backfill to the bedrock contact. The wells would not be over 100 feet deep. Well casings would be constructed of polyvinyl chloride (PVC). Stainless steel submersible pumps equipped with electronic sensors would be installed to maintain optimum drawdown of the water table.

Existing and newly constructed dewatering horizontal drains in the pit highwall would be used at closure. Based on additional hydrogeologic evaluations at the time of closure, horizontal drains drilled from the floor of the pit into target zones behind the pit highwall may also be utilized (GSM, 2002). The horizontal drains would be constructed by drilling 4-inch to 6-inch-diameter boreholes, into which 2-inch to 4-inch-diameter PVC pipes would be inserted. The PVC pipes would be perforated within the targeted dewatering zones, and then sealed off from the remainder of the open boreholes to minimize the formation of acid. The horizontal drains would be used in combination with the two pit highwall wells, but would not require individual pumps. Instead, the discharge lines would be manifolded into a common conveyance that would report to a collection/pumping station. The discharge would be routed by pipeline to the permanent water treatment plant with other pit water. The pit highwall wells would be utilized as necessary for dewatering and highwall stability.

A dewatering monitoring program would be implemented to monitor progress of the dewatering, evaluate the effectiveness of the system, and document the volume and quality of water pumped from the pit.

2.4.2.4 Stability and Safety Concerns

The No Pit Pond Alternative was analyzed for stability and safety in the 1997 Draft EIS, Chapter IV, Section IV.A.6. A new pit design has been implemented since then with different pit highwall angles and blasting techniques. Previous pit slopes were mined at 45 degrees in sediments and 49 degrees in breccia. The steeper pit highwall has been mined at 53 degrees in sediments and 60 degrees in breccia. These steeper slopes have been possible by using pre-split and controlled blasting within 50 feet of the pit highwall and scaling of the pit highwall with an excavator or by hand. Controlled blasting results in a pit highwall where joints, fractures and the highwall rock are less disturbed compared to the previous blasting methods used at GSM. As a result not only is a steeper pit highwall possible, but the highwall is stronger and safer. There is considerably less broken and fractured rock left on the highwall as a result of controlled blasting and scaling. GSM has not proposed any other specific measures to maintain or improve pit highwall stability after closure. No major pit highwall failures were predicted in the 1998 Final EIS. Pit highwall dewatering wells and horizontal drains would continue to be operated as required to release pore pressures in the open pit highwall to minimize the potential for minor pit highwall failure. Additional information regarding pit highwall stability is included in Section 4.2.1.2.

Abrupt pit perimeters would be bermed and fenced. Public safety after mining would be ensured through fences, locked gates, warning signs, and on-site maintenance personnel.

Personnel that would monitor the site for safety and security would include persons on site for operating water treatment facilities and long-term monitoring activities, including the dewatering system, reclamation cover system, surface water diversions, and noxious weeds.

2.4.2.5 Surface Water Management

As part of the final reclamation of the site, GSM would construct berms and surface water diversions to minimize surface water entering the open pit. Storm water diversions would be constructed around the pit capable of handling a 100-year, 1-hour storm event. Most storm water would be diverted away from the pit; less than 1 percent would enter the pit (Telesto, 2003a). Surface water that enters the pit would infiltrate into the backfill and be removed by the dewatering system.

2.4.2.6 Reclamation Requirements

Open pit reclamation activities that would be completed under this alternative (GSM, 2002) are:

- Portions of the underground mine would be closed during and at the completion of Stage 5B.
- The pit would be backfilled with 100 feet of crusher reject from the 4,525 to the 4,625-foot elevation.
- Berms would be constructed on the pit bottom to protect workers from rocks raveling and sloughing off the highwall.
- GSM has proposed using a 3-foot layer of soil, as currently approved for the waste rock dumps, for reclaiming the 1.3-acre flat working surface in the pit bottom.
- Major benches that have sufficient width to allow machinery access, and which are not likely to become buried with rubble from the pit highwall over time, and pit haul roads would be capped with the 3-foot-thick soil cover and revegetated (53 acres, 7 acres already reclaimed, 60 acres total).
- In addition, 68 acres of miscellaneous associated disturbance (outside the pit) would be reclaimed under the existing reclamation plan. One hundred fifty-eight acres would be left unrevegetated in the pit.
- A two- to three-well dewatering system would be constructed.
- Abrupt pit perimeters would be bermed and fenced.

- Trees would be planted around the pit perimeter.
- Oxidized benches containing enough fine material to support plant life would be seeded and planted with trees where safety allows.
- Berms and storm water diversions would be constructed around the pit perimeter capable of handling a 100-year, 1-hour thunderstorm event.
- Warning signs would be placed around the pit perimeter.
- Dewatering wells and horizontal drains would be installed based on additional hydrologic evaluations at closure.
- Two horizontal excavations would be constructed for bats. A number of large and small raptor cavities would be constructed in the oxidized portion of the upper highwall. The exact location and configuration of the raptor cavities and bat excavations would be determined near the end of mine life when stable portions of the pit with suitable aspects can be most accurately identified.

The following table summarizes the pit backfill quantity requirements as well as cover soil, revegetation and dewatering needs of this alternative:

COMPONENT	Quantity	Units
Sump Material	111,000	cubic yards
Pit Backfill	0	cubic yards
Cover Soil [1]	290,400	cubic yards
Dewatering System	2-3	wells
Backfill Depth (4,525-4,625)	100	feet
Pit Area Revegetation [2]	60	acres
Area Unrevegetated	158	acres

[1] Cover soil is for 60 pit acres at 3-foot thickness on a flat surface.
[2] Includes 53 acres of pit roads and benches, 7 acres already reclaimed, and a 1.3-acre flat working surface in the pit bottom.

2.4.3 Partial Pit Backfill With In-Pit Collection Alternative (Proposed Action)

This updated version of the Partial Backfill Alternative analyzed in the 1997 Draft EIS incorporates current site conditions and several modifications submitted by GSM (GSM, 2002). As conceptually described in the 1997 Draft EIS, Chapter II, Section II.B.7, this alternative involves backfilling the GSM pit to a free-draining elevation on the east rim of the pit with previously excavated waste rock and recontouring the upper pit highwall to 2H:1V slopes. The entire area would be graded to a free-draining surface. A 4-foot reclamation cover system was to be placed over the graded area and revegetated. Pit dewatering wells installed through the backfill coupled with water treatment would be required to maintain the pit as a hydrologic sink. Additional details of the 1997 Draft EIS Partial Backfill Alternative are presented in this SEIS Section 2.3.2.

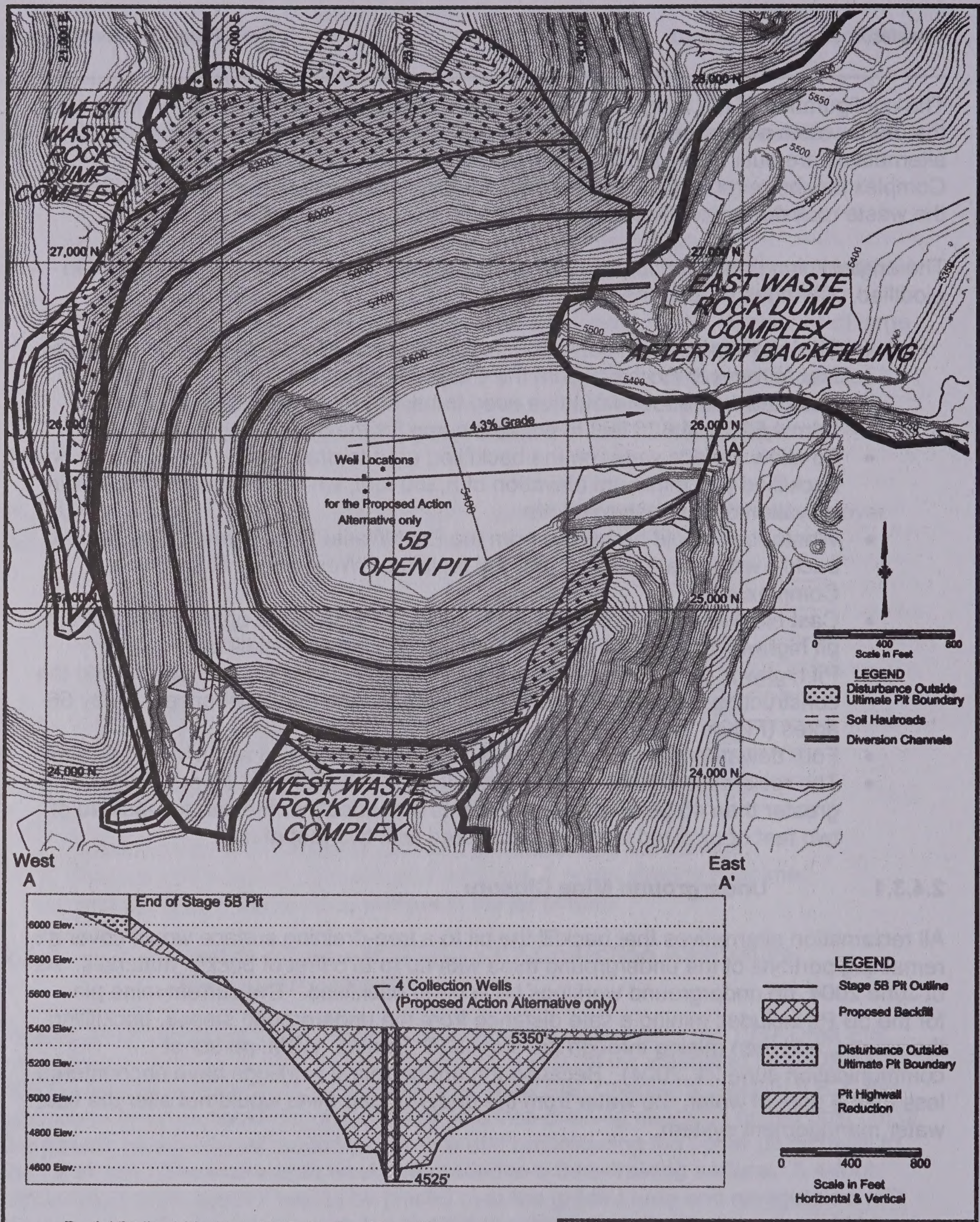
The configuration of the Stage 5B pit design has changed to enhance safety, improve the ore to waste extraction ratio, and target ore zones. Modifications common to all alternatives are outlined in Section 2.2.4. In addition, the West Waste Rock Dump Complex has been reclaimed, and the reclamation cover system has been modified on the waste rock dump complexes to a 3-foot soil cover.

The original plan presented in the 1997 Draft EIS, Chapter II, Section II.B.7 has been modified. Changes include the following:

- The elevation of the floor of the pit would be lowered to an elevation of 4,525 feet to recover more ore from the Stage 5B Pit.
- Selected waste rock would be used to backfill the lower 100 feet of the pit from 4,525 to 4,625 feet to act as a sump for the dewatering system.
- To allow surface water on the backfilled area to drain freely, the pit would be backfilled to a minimum elevation of 5,350 feet, which is the current low point elevation of the eastern pit rim.
- Waste rock would be hauled from the East Waste Rock Dump Complex. No backfill would be obtained from the reclaimed West Waste Rock Dump Complex.
- Cast blasting and dozing would be utilized to reduce the upper portion of the pit highwall to a 2H:1V slope rather than hauling all backfill material.
- Pit highwall reduction to 2H:1V slopes using cast blasting and dozing and the construction of soil haul roads would increase the pit disturbance area by 56 acres (Figure 2-4).
- Four dewatering wells would be used to maintain the pit as a hydrologic sink.
- The reclamation cover would be changed to a 3-foot-thick layer of soil with greater than 45 percent rock fragments amended into the surface instead of two feet of oxidized waste rock covered with two feet of soil.

2.4.3.1 Underground Mine Closure

All reclamation alternatives that backfill the pit to a free-draining surface would cover all remaining portions of the underground mine with up to 875 feet of backfill materials. As of June 2004, no underground workings have been backfilled. The current mine plan for the 5B Pit includes mining a safe distance from the underground stopes, backfilling the stopes, and then mining through the stopes (S. Dunlap, GSM, personal communication June 21, 2004). Because the underground workings have encountered less than 5 gpm of water, the water from the underground mine would not alter the final water management system.


21,000 E
22,000 E
23,000 E
24,000 E
28,000 N
27,000 N
26,000 N
25,000 N
24,000 N
WEST WASTE ROCK DUMP COMPLEX
EAST WASTE ROCK DUMP COMPLEX AFTER PIT BACKFILLING
5B OPEN PIT
4.3% Grade
Well Locations
for the Proposed Action Alternative only
A
A'
6200
6000
5800
5700
5600
5400
5500
5550
5600
5400
5350
0
400
800
Scale in Feet
LEGEND
Disturbance Outside Ultimate Pit Boundary
Soil Haulroads
Diversion Channels
West
A
East
A'
End of Stage 5B Pit
6000 Elev.
5800 Elev.
5600 Elev.
5400 Elev.
5200 Elev.
5000 Elev.
4800 Elev.
4600 Elev.
4 Collection Wells
(Proposed Action Alternative only)
5350'
4525'
LEGEND
Stage 5B Pit Outline
Proposed Backfill
Disturbance Outside Ultimate Pit Boundary
Pit Highwall Reduction
0
400
800
Scale in Feet
Horizontal & Vertical

Partial Pit Backfill with In-Pit Collection Alternative would have four 800-875 foot dewatering wells drilled to approximately the 4525-foot elevation.

Partial Pit Backfill with Downgradient Collection Alternative would have no in-pit wells.

Partial Pit Backfill Alternatives

FINAL
PARTIAL PIT BACKFILL
CONFIGURATION

Figure 2-4 PPB-backfill-xsec.dwg

FIGURE 2-4

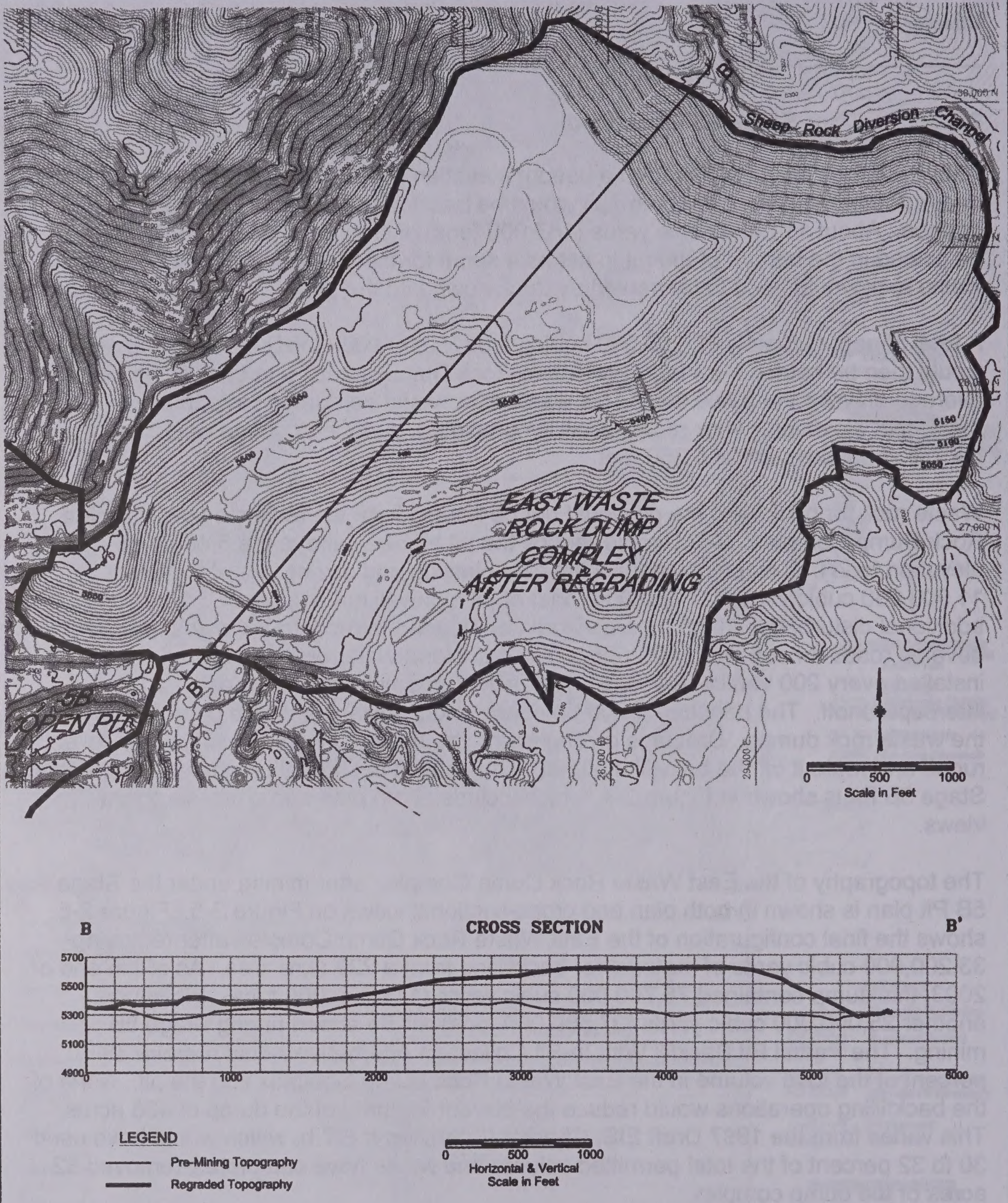
2.4.3.2 Stage 5B Pit Backfill

After the Stage 5B Pit is mined to a bottom elevation of 4,525 feet and portions of the underground mine are closed, the pit would be backfilled to establish a free-draining surface. About 111,000 cubic yards (167,000 tons) of crusher reject waste rock would be placed in the bottom of the pit to act as a sump for the dewatering system. This waste rock would need to be hauled by truck down into the pit.

A total of approximately 33,200,000 cubic yards (50,000,000 tons) of additional material would then be hauled from the East Waste Rock Dump Complex to backfill the pit to an average elevation of 5,400 feet. This waste rock would be dumped into the pit from the 5,400-foot elevation. After reclamation is completed, surface drainage would exit the pit backfill at an elevation of 5,350 feet.

Waste rock for backfilling the pit would not be hauled from the reclaimed West Waste Rock Dump Complex. GSM would reduce the pit highwall above the 5,400-foot elevation to 2H:1V slopes by employing cast blasting and dozing. Approximately 11,900,000 cubic yards (17,850,000 tons) of pit highwall material and 56 acres of additional disturbance in the pit area would be needed to recontour these slopes and develop roads for soil distribution (Figure 2-4). Storm water diversions would be installed every 200 vertical feet down the backfill slope to minimize erosion and to intercept runoff. The benches would be constructed similarly to those constructed for the waste rock dumps. Drainage diversions on the benches would be sloped to collect runoff and route it off the backfill material. The final pit configuration after backfilling the Stage 5B Pit is shown in Figure 2-4, which includes both plan and cross-sectional views.

The topography of the East Waste Rock Dump Complex after mining under the Stage 5B Pit plan is shown in both plan and cross-sectional views on Figure 2-5. Figure 2-6 shows the final configuration of the East Waste Rock Dump Complex after removing 33,200,000 cubic yards of material for backfilling from a 222 acre area. As of the end of 2003, this dump contained 76,700,000 cubic yards (114,750,000 tons). However, another 25,000,000 cubic yards (37,500,000 tons) will be added during Stage 5B mining. The Partial Pit Backfill With In-Pit Collection Alternative would remove 33 percent of the total volume in the East Waste Rock Dump Complex into the pit. None of the backfilling operations would reduce the current footprint of the dump of 438 acres. This varies from the 1997 Draft EIS, Chapter II, Section II.B.7.b, which would have used 30 to 32 percent of the total permitted volume and would have completely removed 82 acres of the dump complex.

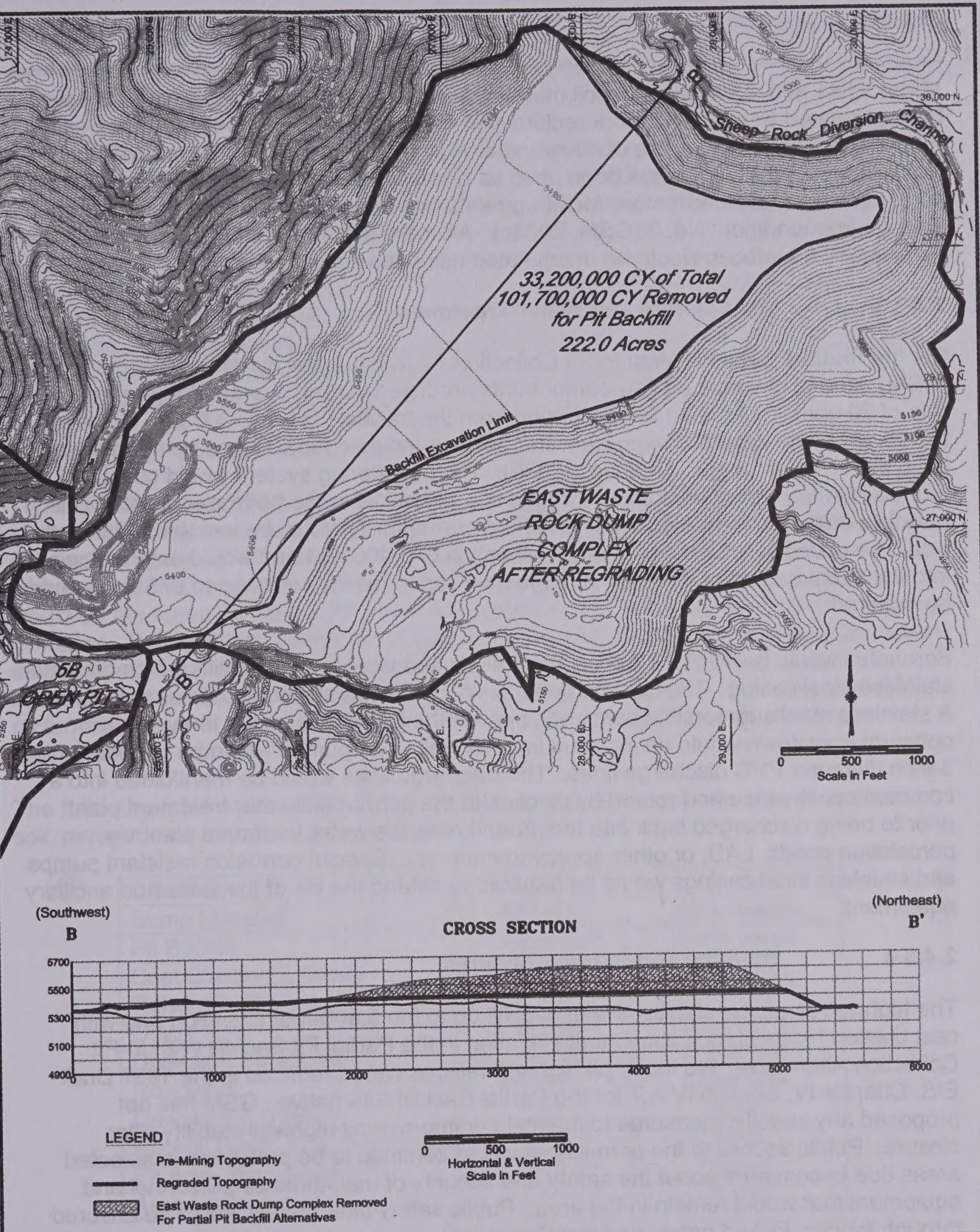

Sheep Rock Diversion Channel
B
EAST WASTE ROCK DUMP COMPLEX AFTER REGRADING
5B OPEN PIT
B
5500
5600
5400
5150
5100
5050
5700
28,000 N
27,000 N
28,000 E
29,000 E
0 500 1000
Scale in Feet
B
CROSS SECTION
B'
5700
5500
5300
5100
4900
0
1000
2000
3000
4000
5000
6000
LEGEND
Pre-Mining Topography
Regraded Topography
0 500 1000
Horizontal & Vertical Scale in Feet

No Pit Pond & Underground Sump Alternatives

EAST WASTE ROCK DUMP COMPLEX TOPOGRAPHY AFTER REGRADING

FIGURE 2-5

Figure 2-5 Rockdump-xsec.dwg


33,200,000 CY of Total
101,700,000 CY Removed
for Pit Backfill
222.0 Acres
Sheep Rock Diversion Channel
Backfill Excavation Limit
EAST WASTE
ROCK DUMP
COMPLEX
AFTER REGRADING
5B
OPEN PIT
B
B'
30,000 N.
29,000 N.
27,000 N.
25,000 E.
26,000 E.
27,000 E.
28,000 E.
29,000 E.
30,000 E.
5350
5300
5400
5450
5150
5100
5050
5000
4950
5500
5550
5750
0
500
1000
Scale in Feet
(Southwest)
B
CROSS SECTION
(Northeast)
B'
5700
5500
5300
5100
4900
0
1000
2000
3000
4000
5000
6000
LEGEND
Pre-Mining Topography
Regraded Topography
East Waste Rock Dump Complex Removed For Partial Pit Backfill Alternatives
0
500
1000
Horizontal & Vertical Scale in Feet

Partial Pit Backfill Alternatives

EAST WASTE ROCK DUMP COMPLEX TOPOGRAPHY AFTER PARTIAL PIT BACKFILL AND REGRADING

FIGURE 2-6

Figure 2-6 PPB rockdump-xsec.dwg

About 1,541,800 cubic yards of soil material would be required to cover the pit areas to be revegetated with a 3-foot-thick reclamation cover. The cover is described in Section 2.3.2. The most likely source of cover material is an area northeast of the East Waste Rock Dump Complex that has been used as a soil borrow area (GSM, 2002). Another potential borrow area with more rock fragments has been identified by GSM north of Tailings Impoundment No. 2 (GSM, 2003c). After the earthwork and soil placement are complete, the surfaces would be revegetated using the approved seed mix.

2.4.3.3 Dewatering and Water Treatment

For the Partial Pit Backfill With In-Pit Collection Alternative, the dynamic systems model (DSM) used to estimate pit flow components predicted that an average long-term flow rate of 20 gpm would need to be pumped from the backfill (Telesto, 2003a). However, the 10-year time weighted average water balance indicated that the pumping rate would be in the order of 15 gpm (Telesto, 2003a). The dewatering system would consist of four dewatering wells constructed through the pit backfill to the bedrock contact. This backfill would be non-homogeneous and the permeability would be variable. The wells would be drilled at an average surface elevation of 5,400 feet and would extend down into the sump backfill at the bottom of the pit. Consequently, wells up to 875 feet would be required.

Boreholes would be 10 to 12 inches in diameter and would be lined with 6-inch diameter stainless steel casing. The bottom of the casing would be slotted in the saturated zone. A stainless steel submersible pump equipped with electronic sensors to maintain optimum drawdown would be installed in each well. The pumps would be connected to 3-inch diameter PVC discharge lines. The discharge lines would be manifolded into a common conveyance and routed by pipeline to the permanent water treatment plant prior to being discharged back into the ground near the water treatment plant via percolation ponds, LAD, or other approved methods. Special corrosion resistant pumps and stainless steel casings would be required to extend the life of the wells and ancillary equipment.

2.4.3.4 Stability and Safety Concerns

The highwall would be stabilized with backfill up to the 5,400-foot elevation and with cast blasted highwall rock above that elevation in the Partial Pit Backfill With In-Pit Collection Alternative. No major pit highwall failures were predicted in the 1997 Draft EIS, Chapter IV, Section IV.A.7 for the Partial Backfill Alternative. GSM has not proposed any specific measures to maintain or improve pit highwall stability after closure. Public access to the permit area would continue to be prohibited in selected areas due to concerns about the safety and security of maintenance personnel and equipment that would remain in the area. Public safety after mining would be ensured through fences, locked gates, and warning signs.

2.4.3.5 Surface Water Management

As part of the final reclamation of the site, GSM would construct berms and surface water diversions around the pit perimeter to remove over 99 percent of surface water entering the area of the backfilled pit (Telesto, 2003a). Surface water that infiltrates into the pit backfill would be removed by four dewatering wells. Surface water diversions would be installed on benches approximately every 200 vertical feet down the slope of the reduced highwall to minimize erosion and intercept runoff (Figure 2-4). The benches would be constructed similar to those constructed for the waste rock dump complexes. Diversions would be sloped to collect runoff and route it off the reclaimed pit area. The storm water diversions would be constructed following the existing approved plan for this type of structure.

2.4.3.6 Reclamation Requirements

The entire 274 acres (218 acres of the pit area plus 56 acres of highwall layback) in the pit backfill, pit highwall reduction areas, and haul roads would be covered with 3 feet of soil and revegetated. The same 3-foot soil cover approved for waste rock dump complex reclamation would be used. Outside the pit area, reclamation requirements would be the same as the No Pit Pond Alternative except at the East Waste Rock Dump Complex. The footprint of the East Waste Rock Dump Complex would remain the same as approved in the 1998 ROD. About 33 percent of the dump's volume would be removed for backfill. No acreage would be completely off-loaded. After placement of reclamation covers, the regraded areas would be fertilized and seeded with an approved seed mix.

The following table summarizes the pit backfill quantity requirements as well as cover soil, revegetation and dewatering needs of this alternative:

COMPONENT	Quantity	Units
Sump Material	111,000	cubic yards
Pit Backfill	33,200,000	cubic yards
Cast Blasting & Dozer Rehandle @ 20%	11,900,000	cubic yards
Cover Soil [1]	1,541,800	cubic yards
Diversion Structures	18,600	linear feet
Roadwork	5,550	linear feet
Dewatering System	4	Wells
Backfill Depth (4,525-5,400)	875	Feet
Pit Area Revegetation [2]	292	Acres
Area Unrevegetated	0	Acres

[1] Cover soil is for 53 acres of flat surface at 3 feet of cover soil and 239 slope acres (plan view adjusted for 2H:1V slope) at 40 inches of cover soil.

[2] This includes 218 plan view acres of the pit plus 56 acres of highwall layback plus 18 acres to adjust plan view acres to 2H:1V slope acres.

2.4.4 Partial Pit Backfill With Downgradient Collection Alternative

This alternative is a variation of the Partial Pit Backfill With In-Pit Collection Alternative. These alternatives backfill the pit to a free-draining surface at approximately the 5,350-foot elevation and reduce the pit highwall above that elevation to 2H:1V slopes. The main difference is that instead of attempting to maintain the backfilled pit as a hydrologic sink by installing wells inside the backfilled area and pumping to remove contaminated groundwater, a system of wells would be operated outside and down gradient from the pit to intercept contaminated groundwater from the pit. The conceptual system would include an estimated 26 or more new capture wells, existing wells in the Tailings Impoundment No. 1 capture system, and at least 10 new monitoring wells (Figure 2-7).

2.4.4.1 Underground Mine Closure

Underground mine closure would be the same as described for the Partial Pit Backfill With In-Pit Collection Alternative (see Section 2.4.3.1 above).

2.4.4.2 Stage 5B Pit Backfill

The backfill plan would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative (see Section 2.4.3.2 above) except that a sump would not be constructed in the bottom of the pit.

2.4.4.3 Dewatering and Water Treatment

The Partial Pit Backfill With Downgradient Collection Alternative would rely on a combination of natural attenuation, mixing with ambient groundwater, and collection and treatment to prevent contaminated pit groundwater from impacting groundwater outside of a permitted mixing zone. This alternative would not collect any water inside the perimeter of the pit. The groundwater level in the pit backfill would be allowed to rise and would discharge along natural flowpaths leading to the regional groundwater system down gradient from the pit. Contaminated groundwater, estimated at 16 gpm, would be collected with ambient groundwater in a series of 26 or more new capture wells plus the existing wells in the Tailings Impoundment No. 1 south pump back system. These wells would be located down gradient from the pit. Up to 121 gpm of captured water would be pumped to the water treatment plant for treatment prior to release (HSI, 2003).

Conceptual new well locations are shown on Figure 2-7. A hydrogeologic study would be conducted to locate the wells, and GSM would have to submit an application to modify the approved mixing zone.

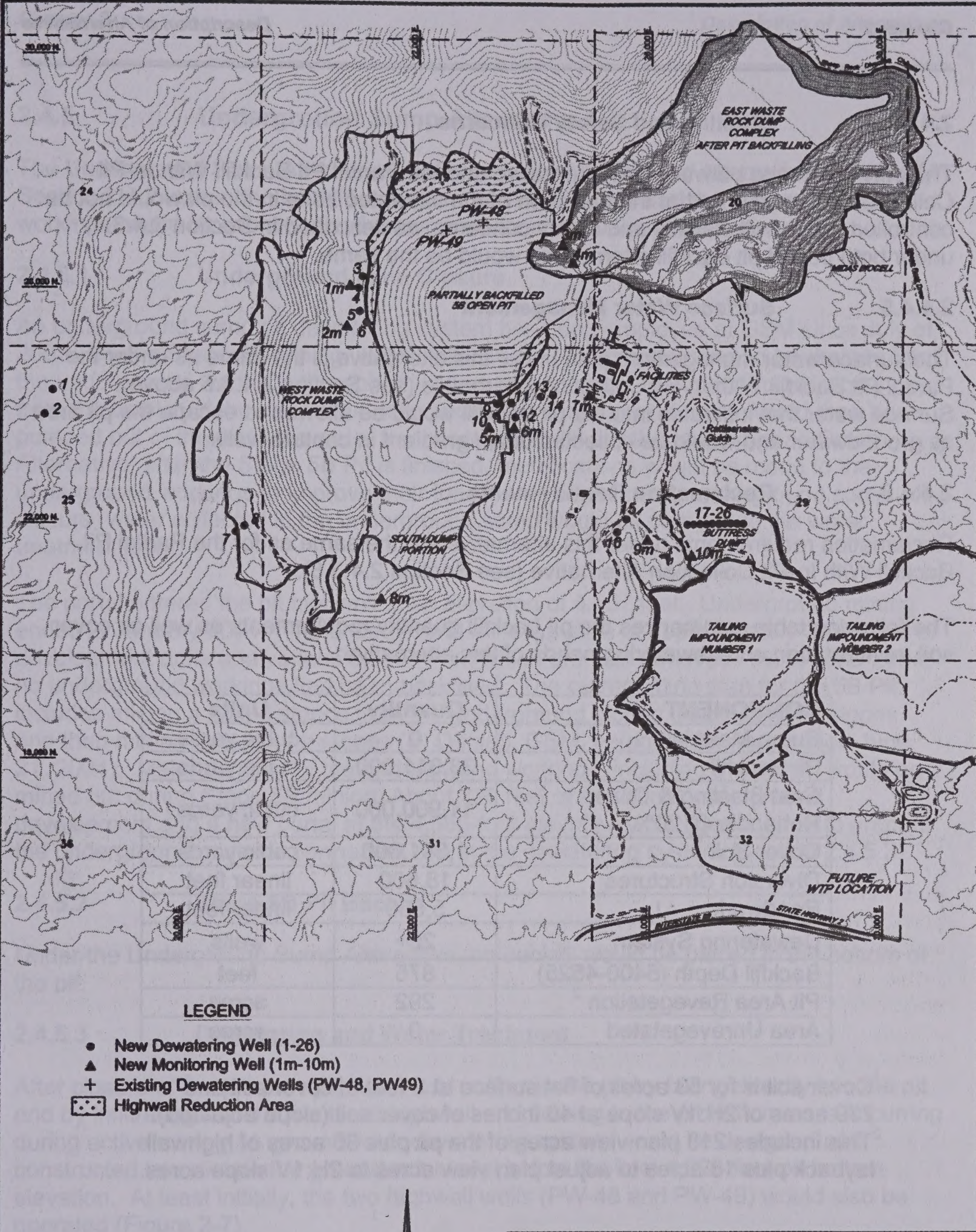

30,000 N.
28,000 N.
22,000 N.
16,000 N.
EAST WASTE ROCK DUMP COMPLEX AFTER PIT BACKFILLING
PW-48
PW-49
PARTIALLY BACKFILLED 5B OPEN PIT
WEST WASTE ROCK DUMP COMPLEX
SOUTH DUMP PORTION
FACILITIES
Rattlesnake Gulch
BUTTRESS DUMP
17-26
TAILING IMPOUNDMENT NUMBER 1
TAILING IMPOUNDMENT NUMBER 2
FUTURE WTP LOCATION
INTERSTATE 80
STATE HIGHWAY 2
MIDAS IMOGELL
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
1m
2m
3m
4m
5m
6m
7m
8m
9m
10m
20
24
25
29
30
31
32
36
LEGEND
● New Dewatering Well (1-26)
▲ New Monitoring Well (1m-10m)
+ Existing Dewatering Wells (PW-48, PW49)
▨ Highwall Reduction Area
0
1200
2400
Scale in Feet

Figure 2-7 Downgradient_wells.dwg

Partial Pit Backfill With Downgradient Collection Alternative

POTENTIAL DOWNGRADIENT DEWATERING WELL LOCATIONS

FIGURE 2-7

2.4.4.4 Stability and Safety Concerns

The only difference between this alternative and the Partial Pit Backfill With In-Pit Collection Alternative is that the elevation of the saturated zone in the pit would not be controlled. Highwall stability and safety concerns, as described in Section 2.4.3.4, under both partial pit backfill alternatives would be the same.

2.4.4.5 Surface Water Management

The surface water management plan under this alternative is the same as under the Partial Pit Backfill With In-Pit Collection Alternative (see Section 2.4.3.5 above). Surface water that infiltrates into the pit backfill would be allowed to escape the pit area as groundwater and would be collected down gradient in capture wells.

2.4.4.6 Reclamation Requirements

Reclamation requirements under this alternative are the same as for the Partial Pit Backfill With In-Pit Collection Alternative (see Section 2.4.3.6).

The following table summarizes the pit backfill quantity requirements as well as cover soil, revegetation and dewatering needs of this alternative:

COMPONENT	Quantity	Units
Sump Material	0	cubic yards
Pit Backfill	33,311,000	cubic yards
Cast Blasting & Dozer Rehandle @ 20%	11,900,000	cubic yards
Cover Soil [1]	1,541,800	cubic yards
Diversion Structures	18,600	linear feet
Roadwork	5,550	linear feet
Dewatering System	26+	wells
Backfill Depth (5400-4525)	875	feet
Pit Area Revegetation [2]	292	acres
Area Unrevegetated	0	acres

[1] Cover soil is for 53 acres of flat surface at 3 feet of cover soil and 239 acres of 2H:1V slope at 40 inches of cover soil (slope adjusted).

[2] This includes 218 plan view acres of the pit plus 56 acres of highwall layback plus 18 acres to adjust plan view acres to 2H:1V slope acres.

2.4.5 Underground Sump Alternative

The Underground Sump Alternative is similar to the No Pit Pond Alternative described in Section 2.4.2, except no backfill would be placed in the pit, and the underground workings would be improved and maintained for continual pit dewatering.

2.4.5.1 Underground Mine Closure

An underground sump pit dewatering system has been employed at GSM since July of 2003. During Stage 5B mining, water collecting in the pit bottom would be drained into the underground workings through drill holes that intercept the underground workings from the bottom of the pit. Water collected in the underground sump would then be pumped out of the pit to the water treatment plant. Under the Underground Sump Alternative, after the Stage 5B Pit is finished, modifications would be made to the underground workings to improve their function as a continuing underground sump. At closure, water collected in the underground sump would be pumped to the water treatment plant.

The portal entered the pit highwall at an elevation of 4,857 feet. Underground mining ended in January 2004. The underground mine consists of approximately 3,000 feet of development drifts and various stopes from which ore was removed. As of June 2004, no underground workings had been backfilled. The current mine plan for the 5B Pit includes mining a safe distance from the underground stopes, backfilling the stopes, and then mining through the stopes (S. Dunlap, GSM, personal communication June 21, 2004). Major portions of the underground workings, including the portal, would be mined out during Stage 5B mining. About 320 feet of additional underground development and a new portal at the 4,550-foot elevation would be required to prepare the underground mine for permanent use in the dewatering system (Section 2.4.5.3).

2.4.5.2 Stage 5B Pit Backfill

Under the Underground Sump Alternative, no backfill would be placed in the bottom of the pit.

2.4.5.3 Dewatering and Water Treatment

After closure of the pit, precipitation could collect in the pit by falling directly into the pit and by infiltrating into the fractured highwall and flowing to the pit bottom as is occurring during active mining. A groundwater dewatering system would be designed and constructed to maintain the groundwater level below the final 4,525-foot pit bottom elevation. At least initially, the two highwall wells (PW-48 and PW-49) would also be operated (Figure 2-7).

Access to the underground workings would be through the new 4,550-foot-elevation portal. The dewatering system would use the existing 14-foot-wide by 14-foot-high underground access road between the 4,450-foot elevation and the 4,500-foot elevation as a sump, which has a total of 500,000 gallons of surge capacity. Submersible pumps at the 4,450-foot elevation would feed station pumps located in a cross-cut at the 4,525-foot elevation. At least one booster pump station at approximately the 5,000-foot bench would be required to provide the necessary lift to carry water out of the pit. Pumps and fittings would be stainless steel, and pipe would be HDPE pipe with sufficient wall thickness to contain the pressure developed within the dewatering system.

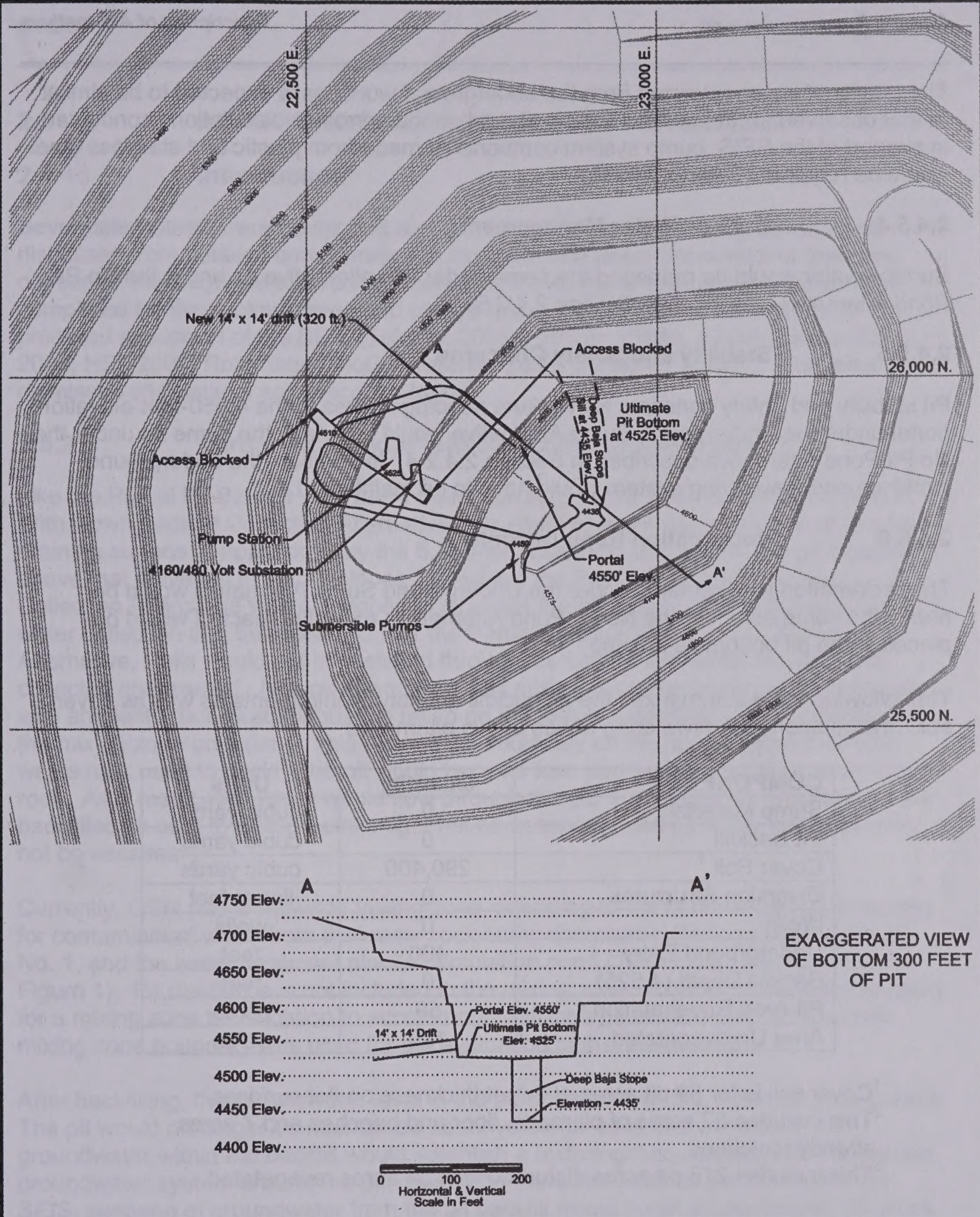
In order to dewater the GSM pit using the underground workings as a permanent sump, the following development and construction work would be required (GSM, personal communication, 2003):

- Installation of a 4,160-volt power line into the pit bottom at the 4,550-foot elevation;
- Construction of a portal at the 4,550-foot elevation in the Stage 5B Pit;
- Construction of 320 feet of 14-foot-wide by 14-foot-high access road to meet the existing underground road;
- Installation and upgrade of ground support in 1,000 feet of underground workings;
- Installation of an auxiliary fan and 900 feet of fiberglass ventilation duct;
- Blockage of the existing underground road in two locations;
- Installation of a substation to drop voltage from 4,160 to 480 volts;
- Installation of submersible pumps at the 4,450-foot elevation;
- Installation of centrifugal station pumps at the 4,525-foot elevation; and,
- Distribution of 480-volt power to pumps and fan.

Figure 2-8 shows the conceptual dewatering system for the Underground Sump Alternative after completion of Stage 5B.

Submersible pumps equipped with electronic sensors would be installed to maintain optimum drawdown of the water table. The discharge lines would be manifolded into a common conveyance pipe that would carry the water to the water treatment plant. Based on the proposed pit bottom at the 4,525-foot elevation, the submersible pumps would be placed approximately 75 feet below the pit bottom to provide an emergency underground storage capacity of approximately 4,000,000 gallons. Once the system is tested and on line, water would be pumped regularly to maintain the water level below the pit bottom.

Data collection from the active pit dewatering program indicates that an average of 30 to 47 gpm of water would have to be removed from the underground workings on an annual basis (GSM, personal communication, 2003).


22,500 E.
23,000 E.
26,000 N.
25,500 N.
New 14' x 14' drift (320 ft.)
A
A'
Access Blocked
Access Blocked
Deep Baja Stope Sill at 4435 Elev.
Ultimate Pit Bottom at 4525 Elev.
Pump Station
4160/480 Volt Substation
Portal 4550' Elev.
Submersible Pumps
4510
4520
4550
4430
4600
4575
4750 Elev.
4700 Elev.
4650 Elev.
4600 Elev.
4550 Elev.
4500 Elev.
4450 Elev.
4400 Elev.
Portal Elev. 4550'
Ultimate Pit Bottom Elev. 4525'
14' x 14' Drift
Deep Baja Stope
Elevation ~ 4435'
EXAGGERATED VIEW OF BOTTOM 300 FEET OF PIT
0
100
200
Horizontal & Vertical Scale in Feet

Note:

The 4857 Portal will be mined out during Stage 5B.

See Figure 2.4 for Complete Pit Cross Section.

Underground Sump Alternative

UNDERGROUND SUMP
DEWATERING PLAN
AFTER STAGE 5B

FIGURE 2-8

Figure 2-8 Pumpstation.dwg

The quality of water extracted from the underground workings is expected to be similar to that observed for the current seeps. Based on the corrosion calculations conducted in support of the SEIS, pump system components made from plastic and stainless steel would be required (Telesto, 2003e).

2.4.5.4 Surface Water Management

Surface water would be managed the same under this alternative as under the No Pit Pond Alternative described in Section 2.4.2.5.

2.4.5.5 Stability and Safety Concerns

Pit stability and safety concerns for workers needing access to the 4,550-foot-elevation portal under the Underground Sump Alternative would be nearly the same as under the No Pit Pond Alternative described in Section 2.4.2.4. In addition, the underground workings and dewatering system would have to be maintained.

2.4.5.6 Reclamation Requirements

The reclamation requirements under the Underground Sump Alternative would be nearly the same as under the No Pit Pond Alternative, except no backfill would be placed in the pit bottom as a sump.

The following table summarizes the pit backfill quantity requirements as well as cover soil, revegetation and dewatering needs of this alternative:

COMPONENT	Quantity	Units
Sump Material	0	cubic yards
Pit Backfill	0	cubic yards
Cover Soil [1]	290,400	cubic yards
Diversion Structures	0	linear feet
Wells	0	wells
Underground Entry	400	feet
Backfill Depth (4,525)	0	feet
Pit Area Revegetation [2]	59	acres
Area Unrevegetated [3]	159	acres

[1] Cover soil is for 59 pit acres at 3-foot thickness on flat surfaces.

[2] This includes 52 acres of pit roads, floor and benches and 7 acres already reclaimed.

[3] This includes 218 pit acres disturbed less 59 acres revegetated.

2.5 ALTERNATIVES CONSIDERED BUT DISMISSED

2.5.1 Introduction

Seven alternatives were developed and evaluated. Three of the alternatives were dismissed from detailed consideration in the SEIS due to environmental or technical concerns. Although the alternatives were dismissed, many technical analyses were completed for these alternatives and can be found in the Technical Memoranda prepared in support of the SEIS (Telesto, 2003a, 2003b, 2003c, 2003d, 2003e, 2003f, 2004; HSI, 2003; Robertson GeoConsultants, 2003; Gallagher, 2003c). The three dismissed alternatives are described below.

2.5.2 Partial Pit Backfill Without Collection Alternative

Like the Partial Pit Backfill With In-Pit Collection Alternative and the Partial Pit Backfill With Downgradient Collection Alternative, this alternative would backfill the pit to a free-draining surface at approximately the 5,350-foot elevation and reduce the pit highwall above that elevation to 2H:1V slopes. However, the Partial Pit Backfill Without Collection Alternative was developed to evaluate the possibility of avoiding long-term pit water collection and treatment. Under the Partial Pit Backfill Without Collection Alternative, wells would not be installed through the backfill and water would not be collected and treated. Natural attenuation and mixing of contaminated pit groundwater with ambient groundwater would be relied on to meet groundwater quality standards at the mixing zone boundary. This alternative would rely on the concept that over time waste rock used to backfill the pit would become less permeable than the surrounding rock. As a result, less water would flow through the pit. Consequently, maintaining the backfilled pit as a hydrologic sink might not be necessary and pit water treatment may not be necessary.

Currently, GSM has a site-wide mixing zone extending to the southern permit boundary for contaminated water from the waste rock dump complexes, Tailings Impoundment No. 1, and the water treatment plant's percolation pond (1998 Final EIS, Appendix 1, Figure 1). Pit discharge is not included in the mixing zone, so GSM would have to apply for a mixing zone modification to accommodate discharge from the pit. The current mixing zone boundary was used for the evaluation of this alternative.

After backfilling, the groundwater level in the pit would slowly rise, saturating the backfill. The pit would no longer be maintained as a hydrologic sink, and eventually the groundwater within the backfill would establish a hydrologic equilibrium with the natural groundwater system around the pit. Based on the water balance performed for the SEIS, seepage of groundwater from the pit backfill would begin approximately 35 years after mining ceases. An equilibrium pit groundwater elevation of 5,260 feet was predicted to be reached approximately 123 years following the cessation of mining (Telesto, 2003a). The discharge rate from the pit was predicted to be approximately 16 gpm.

As the groundwater level rose in the pit backfill it would migrate into fractures, faults and other geologic structures in the bedrock forming the former pit highwall. When the groundwater level rose above the 5,187-foot elevation, it would seep east along and across the structures, beneath the low point on the eastern rim of the pit, into the Tertiary debris flow/colluvial aquifer (URS, 2001). This is identified in Section 3.3.1.4 as the primary pit flowpath (HSI, 2003). The Tertiary debris flow/colluvial aquifer is a buried gravel deposit forming a continuous pathway from the east side of the Range Front Fault, through Rattlesnake Gulch, where it blends with alluvial gravel deposits beneath Tailings Impoundment No. 1, reaching to the Jefferson River alluvial aquifer (Chapter 3, Section 3.3.1.5; and HSI, 2003). The existence and extent of the Tertiary debris flow/colluvial aquifer flow path was mapped from geologic data in a number of detailed studies conducted by GSM and its consultants for a variety of purposes since 1985 (SHB, 1985 and Golder, 1995a) (see Figure 3-8). The pit flow path connecting to the Tertiary debris flow/colluvial aquifer was evaluated for this SEIS (HSI, 2003)

Analysis of the geology and hydrogeology of the pit and surrounding bedrock indicated that secondary flow paths consisting of faults, fractures and other geologic structures could also provide pathways for seepage from a backfilled pit (HSI, 2003). These structures exit the pit in all directions. These same structures provide the pathways for the seeps and springs discharging into the pit during mining (Gallagher, 2003b). They are called secondary because:

- Their extent and continuity outside the pit may be limited or not completely mapped;
- Their hydrologic connection to existing surface water or groundwater features may be indirect; or,
- Their importance is inferred primarily by association with ferricrete deposits or high yield wells, which provide indirect evidence of a pathway.

The agencies assumed that less than 10 percent of the pit water would likely flow south along the Range Front Fault and other secondary flow paths.

A groundwater mixing model was developed for the primary pit flow path from the pit to the Jefferson River alluvial aquifer (Telesto, 2003e). The model included mixing with ambient groundwater in the Tertiary debris flow/colluvial aquifer, and from precipitation. Due to the naturally acidic groundwater and coarse texture of the Tertiary debris flow/colluvial aquifer beneath Rattlesnake Gulch, attenuation is believed to be minimal, and thus was not included in the model. This analysis indicated that primary groundwater quality standards for cadmium, copper, nickel and zinc, and secondary standards for sulfate and manganese would be exceeded at the current mixing zone boundary at the Jefferson River alluvial aquifer (Telesto, 2003e). Thus, compliance with groundwater quality standards could not be achieved without capture and treatment.

Analysis found that groundwater in a backfilled pit would also migrate along secondary pathways such as faults, fractures, and other geologic structures in the bedrock (HSI, 2003). There is no natural attenuation capacity, or ability to reduce the metals concentrations, available in the bedrock (Schafer and Associates, 1996). If collection and treatment are added to remedy this deficiency, this alternative becomes the same as the Partial Pit Backfill With Downgradient Collection Alternative. Consequently, this alternative was dismissed because compliance with groundwater quality standards could not be guaranteed without downgradient or in-pit collection of contaminated groundwater.

The reclamation requirements for the Partial Pit Backfill Without Collection Alternative would be the same as the Partial Pit Backfill With Downgradient Collection Alternative.

2.5.3 Partial Pit Backfill With Amendment Alternative

The Partial Pit Backfill With Amendment Alternative was developed to try to avoid the need for long-term pit water collection and treatment. Like the Partial Pit Backfill With In-Pit Collection and Partial Pit Backfill With Downgradient Collection alternatives, this alternative would backfill the pit to a free draining surface at approximately the 5,350-foot elevation and would reduce the pit highwall above that elevation to 2H:1V slopes. In this alternative, the chemical and the physical properties of the backfill would be conditioned to minimize groundwater flow and to prevent the generation of ARD through in-situ neutralization. The addition and mixing of sufficient lime to the waste rock could increase the pH of the pore water, providing a less favorable environment for pyrite oxidation and/or minimizing metals mobility. Lime would be a mixture of calcium carbonate and calcium oxide mixed to DEQ specifications for lime amendment for waste rock (DEQ, 1990). The goal would be to minimize the contaminant load that would be generated and transported in seepage from the pit, allowing compliance with applicable groundwater quality standards at the mixing zone boundary.

In this case, all material used to backfill the pit to a free-draining surface (33,300,000 cubic yards) would be hauled into the pit, placed in 2-foot lifts, and amended with lime at the rate of 200 tons of lime per 1,000 tons of waste rock backfill. This amendment rate would have about twice the neutralization potential needed for the waste rock backfill. Cast blasted and other backfill placed above the daylight level would not be amended.

The amended backfill would be constructed in lifts in the following sequence:

- Waste rock would be hauled from the East Waste Rock Dump Complex down into the pit;
- Waste rock would be dumped and spread in 2-foot-thick lifts;
- Lime would be hauled into the pit;
- Lime would be spread evenly over the top of the active backfill lift;
- Lime would be ripped into the backfill; and,
- The amended backfill would be compacted.

Backfill above the daylight level would be placed as described in the Partial Pit Backfill With In-Pit Collection Alternative. Compaction of the backfill placed below the free-draining grade would reduce the permeability of the backfill, which would restrict groundwater movement into and through the amended waste rock. A relatively low permeability plug of amended waste rock would be constructed within the pit.

Evaluation of this alternative revealed potential problems. Evidence was not found of cases where lime amendment of strongly ARD-generating rock or waste material was completely successful in controlling ARD production over a long period of time (Gallagher, 2003c). Some of the problems with lime amendment of ARD material could include:

- Lime amendment of ARD-impacted soils has been shown to be effective in surface reclamation, but not in a mass of waste rock as large as the GSM pit backfill.
- The chemical benefits of lime amendment may be short-lived, since some of the potentially reactive lime tends to become encapsulated by secondary mineral deposits of gypsum and hydroxides, rendering it ineffective in maintaining a non-acidic pH.
- The precipitation of secondary minerals from neutralization reactions would occur, but could not be counted on to form a complete low-permeability plug throughout the waste rock backfill.
- Locally, the formation of low permeability layers in the amended material due to plugging of pore spaces by iron hydroxide precipitates could lead to perching of groundwater recharge and ineffectual in-situ treatment by the amendment (Sonderegger and Donovan, 1984).
- Even if lime amendment would effectively maintain a nearly neutral pH, some contaminants, such as arsenic, selenium, sulfate and zinc, would remain mobile or could become more mobile under these conditions and would be available for groundwater transport out of the pit.
- The incorporation of the lime with the waste rock by ripping is not a perfect mixing process, resulting in many localized spots of ARD generation, which may be mobilized by groundwater (Dollhopf, 1990; Spectrum Engineering, 1996).

A pit backfill analog study did not find any cases, successful or unsuccessful, of mine reclamation programs using amended pit backfill (Kuzel, 2003; Gallagher, 2003c). Most mines do not have enough backfill history to draw any conclusions. Since the evidence did not support the premise that ARD production and migration from amended backfill could be controlled, seepage of ARD from the backfilled pit could occur. The process through which ARD from a backfilled pit migrates down the primary and secondary groundwater flow paths was described in Section 3.3.7.2. Analysis indicated that without downgradient groundwater capture, compliance with groundwater quality standards for certain constituents could not be guaranteed (Telesto, 2003e).

A safety risk was identified for construction workers attempting to implement this alternative because all backfill material below the daylight level would have to be hauled down into the pit via a steep road rather than being end dumped at the 5,400-foot elevation. While the addition of lime would neutralize the acidic quality of the mine waters for some period of time, it would also increase the mobility of other problem metals such as arsenic and zinc, potentially resulting in other environmental consequences. Due to the groundwater quality risk associated with this alternative and the high level of uncertainty, it was dismissed from further consideration.

The reclamation requirements for the Partial Pit Backfill With Amendment Alternative would be the same as the Partial Pit Backfill With Downgradient Collection Alternative except that about 10,000,000 tons of lime would be needed. This lime would have to be mined or purchased from regional suppliers and hauled to the site.

2.5.4 Pit Pond Alternative

The possibility of creating a pit pond with biologic mitigation was analyzed. The objective would be to design a pond that could sustain aquatic life and provide beneficial uses once it was developed. In the Pit Pond Alternative, the pit would passively fill with precipitation, groundwater, and runon water flowing into the pit. The design objectives would be to construct a pit pond that would remain as stable as possible year-round and to treat the water in the pit with microbes, nutrients, etc. As presently understood, a steady-state pit pond 110 feet deep would have a pool elevation of approximately 4,635 feet and would have roughly 30,000,000 gallons of storage (Telesto, 2003a).

The physical and chemical evolution of the pit pond would be monitored as the filling occurred. Depth profiles for temperature and electrical conductivity would be determined from sampling stations in the pit pond. The sample locations would be chosen to determine the effect of acid water on the electrical conductivity profile. During winter months, the freezing and thawing of the pond surface would be monitored. Samples would also be collected for various chemical analyses. Climate data would be collected with an on-site weather station. These data would be used to assist in modeling efforts and planning.

Design of the pit pond would involve applying scientific knowledge and engineering concepts to develop a final closure plan. Design work would consist of reducing uncertainties involved with the pit pond and gaining an understanding of the mechanisms that would operate in the pit pond. Some test work has been completed on this concept. But, the necessary work required to propose an in-situ treated pit pond is not complete at this time. As a result, a contingency to pump and treat water would be needed to drain the pond as in the Underground Sump Alternative.

Due to the lack of detailed studies to support such an action and the current uncertainties of success associated with a pit pond, the in-situ treatment concept could not be fully developed. Consequently, the pit pond concept was modified to incorporate a minimal pit pond with pumping and external water treatment.

2.5.4.1 Pit Pond With Pump and Treatment Alternative

The Pit Pond With Pump and Treatment Alternative is a no pit backfill option that has the objective of creating a pond of water inside the pit. The quality and level of the water allowed to accumulate in the pit would be managed by pumping from the pond in the pit as it forms, treating this water in the water treatment plant, and then recirculating treated water back into the pond to keep the water quality at an acceptable level. Because this concept would need to be tested in practice, a fully functional contingent underground sump collection and removal system would have to be made available to empty the pond and treat the water in case this alternative failed to provide adequate groundwater protection, as in the Underground Sump Alternative.

The pumping capacity would be designed to accommodate 65 gpm of water from the pit. Pumps could be stationed on a floating barge or inside the underground workings. If it became necessary to dewater all of the underground workings, a portable submersible pump could be advanced down the underground road. In any case, some modification of the underground mine would be necessary to accommodate the pit pond. This might include constructing a new portal at an alternative elevation. Also, portable substations, fans, and pumping equipment would need to be removed from the sections of underground workings that would be below the pond elevation. HDPE pipes would be left in place.

Under the pump and treat concept, the water level in the pit would be kept as low as possible. Although a design water level was not determined for this concept, it would be well below the elevation of 4,635 feet, the point where evaporation would keep the pond at a steady-state. If treated water from all sources was returned to the pit, it would take approximately five to six years for the water level to reach the steady-state elevation of approximately 4,635 feet (Telesto, 2003e).

The water quality of the pond would initially be similar to that observed for the current seeps. If water were left in the pond for long periods of time, evaporation would concentrate constituents. Thus, a pumping rate that balances inflows and evapoconcentration effects would be desired, but this would depend on the chosen treatment option. This pumping rate could be adjusted to meet a certain water quality desired for the treatment plan. Based on the corrosion calculations completed, pump system components made from plastic and stainless steel would be required.

Under the Pit Pond Alternative, the pit would remain a hydrologic sink above the pond elevation without the potential problems associated with constructing and operating a pumping system in acid producing backfill. However, even under this alternative, wells and drains in the highwall might still be used to target dewatering zones.

A water balance calculated for the pond was similar to that calculated for the No Pit Pond Alternative (Telesto, 2003a). Based on the water balance, the pond elevation would be well below the 5,050-foot elevation, which is the lowest contact with the Sunlight Fault and the point where water would be expected to begin escaping from the pit. The agencies have assumed that no seepage out of the pit would be expected if the pond elevation were at the 4,635-foot level.

There were concerns with this alternative which could not be addressed without actual field experimentation, data collection and additional technical analysis, including:

- The treated water returned to the pit could re-acidify.
- The equilibrium pit water level could fluctuate seasonally and annually and with cycles in weather.
- The continuing influx of acid salts from highwall runoff and the concentration effect from evaporation could affect the ability to maintain a treated pool.
- Given the uncertainties with the water chemistry and treatment capacity, applicable water quality standards might not be met.
- A contingency plan to improve the underground workings to dewater the pit would be needed.

Precipitation and groundwater that come into contact with the pit rock quickly acidify and become ARD. However, no studies have been performed on the interaction between treated water and the pit rock. The filling of a pit by groundwater would be a dynamic process involving the specific geometry of the pit, uncertain water chemistry, and rates of change in several other parameters.

Slope stability analyses show that the highwall would not be susceptible to mass failures under the conditions imposed by this alternative. Highwall stability would be the same as for the Underground Sump Alternative or No Pit Pond Alternative.

Reclamation requirements would be the same as for the Underground Sump Alternative.

The Pit Pond With Pump and Treatment Alternative has no clear advantage over the Underground Sump Alternative. At this point, without further technical review, any pond concept could only be considered by the agencies on a trial basis. Consequently, this alternative was dismissed.

2.6 RELATED FUTURE ACTIONS

Related future actions and impacts are discussed in Cumulative Impacts Section 4.7.

2.7 WATER TREATMENT AND CONTROL APPLICABLE TO ALL ALTERNATIVES

2.7.1 Collection and Treatment of Contaminated Groundwater

A water treatment system design was analyzed in the 1997 Draft EIS, Appendix A and approved in the 1998 ROD. Although quantities of water and the degree of contamination may vary between alternatives, all options require long-term measures to collect and treat contaminated groundwater, which either flows through or originates in the area of the mined-out pit. All alternatives carried forward in this SEIS have provisions for a capture system with pumps and pipes to collect water and convey it to the treatment plant. The projected reliability and effectiveness of the groundwater capture systems vary among the alternatives.

The 1997 Draft EIS, Chapter IV, Sections IV.B.7.b and IV.B.6.b estimated that 50 to 102 gpm of pit water would need to be captured and treated. In the SEIS, projected collection and treatment rates range from 15 to 47 gpm for alternatives involving capture within the pit. Capture rate requirements for the Partial Pit Backfill With Downgradient Collection Alternative would be higher, due to the collection of additional ambient groundwater. The collection rate for the Partial Pit Backfill With Downgradient Collection Alternative would range from 16 to 121 gpm, depending on the location and efficiency of capture wells (HSI, 2003).

2.7.2 Water Treatment Plant

In all alternatives, water treatment would be required. The water treatment facility has already been permitted. In addition, GSM has posted a bond with the agencies for long-term water treatment. Although water treatment facilities with capacity to treat approximately 100 gpm currently exist in the mill building, GSM intends to replace this facility with a new water treatment plant after the mine closes. As reported in the 1997 Draft EIS, Map I-2, the new treatment plant would be located south of Tailings Impoundment No. 2 and would be designed to treat 102 gpm from the pit area (Figure 2-7).

2.7.3 Surface Water Management

GSM manages storm water runoff on site with lined and unlined diversions that route water around mine facilities, and with berms and swales that promote infiltration of runoff into the ground. All alternatives would employ provisions to divert surface water around the pit area, whether it is backfilled to a free-draining configuration or left open. Diversions constructed on acid-producing materials would be lined.

As part of the final reclamation of the site, GSM would construct permanent storm water controls. Erosion and sedimentation controls would be designed and implemented where necessary. The erosion and sedimentation control plan would consist of settling ponds and a network of associated collection and diversion channels (GSM, 1995b).

2.7.4 Monitoring

The water resources monitoring program currently in place (GSM 2003 annual report) would be modified at the end of mining, in coordination with DEQ and BLM. Facility-specific monitoring includes:

- Tailings Impoundment No. 1 seepage containment systems;
- Tailings Impoundment No. 1 and No. 2 area wells;
- Pit and waste rock dump complex area wells and seeps;
- Springs and surface water;
- Private residence wells; and,
- Diversion inspections.

Reclamation monitoring includes:

- Cover thickness evaluation;
- Revegetation success monitoring, including noxious weeds;
- Erosion monitoring; and,
- Steam vent monitoring.

2.7.5 Permanent Remediation Staff

All of the alternatives that have been evaluated require perpetual site staffing to monitor, operate, and maintain the water capture and treatment facilities, diversions and other erosion controls, revegetation success, weed control, etc. The permanent staff would range from 2 to 5 employees, depending on the alternative selected.

2.7.6 Return Diversion

The 1998 ROD approved the No Pit Pond Alternative in combination with the Return Diversion Alternative for the East Waste Rock Dump Complex. The diversion has already been constructed. Hence, the Return Diversion Alternative will be common to any of the pit closure alternatives.

Under the Return Diversion Alternative, Sheep Rock Creek is being diverted around the east end of the East Waste Rock Dump Complex and then reconnected with the unnamed tributary to the north on the east side of the dump (Figures 1-2 and 2-5).

2.8 SUMMARY OF IMPACTS FOR ALTERNATIVES

A detailed evaluation of impacts resulting from the Proposed Action and alternatives is provided in Chapter 4. Table 2-2 summarizes and compares the impacts of each alternative considered.

Table 2 - 2 Summary Comparison of Impacts Under the Proposed Action and Alternatives

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Technical Issues				
Design & constructability of the alternative				
Proven design	Backfilling with 111,000 cubic yards of acidic waste rock this volume of material to a depth of 100 feet is a proven design. Dewatering this volume of material to a depth of 100 feet is a proven design.	Backfilling with 33 million cubic yards of acidic waste rock and cast blasting and dozing the highwall to a 2H:1V slope is technically feasible. Dewatering waste rock backfill from a depth of up to 875 feet has not been proven.	Similar as Partial Pit Backfill With In-Pit Collection Alternative. Pumping out of downgradient drainages in natural geologic formations up to 200 feet deep is done regularly, but overall 95 percent capture may not be achievable.	Not applicable. Maintaining hydrologic connection between the pit bottom and an underground sump 25 to 75 feet below the pit and pumping from the sump have been done successfully at GSM and other mines.
Design & constructability of the alternative				
Ability to construct the alternative at GSM	Problems with constructing this alternative would be minimal.	There would be more problems developing and implementing this alternative than the No Pit Pond Alternative because of the larger volume and depth of backfill needed, the amount of cast blasted material, and the problems drilling dewatering wells in up to 875	There would be more problems developing and implementing this alternative than the No Pit Pond Alternative because of the larger volume and depth of backfill needed and the amount of cast blasted material. Installing dewatering wells in downgradient drainages in natural geologic formations up	GSM has developed and maintained an underground mine, including an underground sump connected to the open pit.

	No Pit Pond (No Action)	**Partial Pit Backfill With In-Pit Collection (Proposed Action)**	**Partial Pit Backfill With Downgradient Collection**	**Underground Sump**
		feet of unconsolidated waste rock in order to maintain the pit as a hydrologic sink.	to 200 feet deep has been done successfully at GSM.	
Pit highwall				
Pit highwall stability	Some portions of the pit highwall would be subject to raveling, talus formation, erosion, and limited sloughing. The overall stability of the pit highwall would be expected to increase over the long term as the rock materials achieve a more stable configuration.	No pit highwall would remain exposed. Backfilling the pit would eliminate pit highwall raveling and sloughing. Cast blasting would enhance the inherent stability of the pit highwall by reducing the slope to 2H:1V. The long-term stability of the pit highwall would be greater than the No Pit Pond Alternative.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative.
Pit highwall maintenance requirements	Raveling and sloughing of the highwall would require periodic maintenance to re-establish the 5,700-foot-elevation safety bench, clear the access road, haul more backfill to create a new working surface in the pit bottom, and move rock to re-establish safety berms. This could occur more than once over the long term.	No highwall maintenance would be needed.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative. Depending on the location of highwall raveling and sloughing, access to the 4,550-foot portal and the underground dewatering system could be lost. The 5,700-foot safety bench and access to the 4,550-foot portal would have to be re-established.
Backfill				
Backfill maintenance requirements	Settling in 100 feet of backfill would be limited to 10 feet. Repairs would be needed to bring the backfill back to grade.	Up to 150 feet of settling could occur in the 875 feet of backfill, with 60-75% of the settling occurring during the backfilling operation. Repairs	Up to 200 feet of settling could occur in the 875 feet of backfill after it is inundated with groundwater. Most settling would occur during the	Not applicable.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
		would be needed to bring the backfill back to grade. Settling in the backfill would affect storm water diversions on the 2H:1V slopes.	backfilling operation, with the remaining settling occurring with inundation over about 100 years. Repairs would be needed to bring the backfill back to grade. Settling in the backfill would affect storm water diversions on the 2H:1V slopes.	
	Raveling and sloughing of the highwall would require periodic maintenance to re-establish the working surface and drill new wells.	The highwall would not ravel or slough.	The highwall would not ravel or slough.	Not applicable.
Underground workings				
Impacts to pit facilities due to subsidence related to underground mining	While subsidence of the underground workings is not expected, localized failures of the walls and ceiling over time could result in subsidence, especially in seep and fault areas where chemical weathering would be increased. Subsidence could cause settling in the 100 feet of backfill, affecting the dewatering wells in the backfill.	Same as the No Pit Pond Alternative. Subsidence could cause settling in up to 875 feet of backfill, affecting the dewatering wells in the backfill.	Similar to the Partial Pit Backfill With In-Pit Collection Alternative except the dewatering wells down gradient of the pit would not be affected.	Same as the No Pit Pond Alternative except localized failures of ceiling and walls in seep and fault areas could occur over time affecting access to the dewatering system in the underground workings.
Groundwater/ effluent management system				
Operation requirements	Two to three wells would be constructed through the	Four wells would be constructed through the pit	The agencies have assumed that an additional 26 capture	No wells would be constructed. Drill holes would

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
(number of wells)	pit backfill about 100 feet deep to the bedrock contact.	backfill up to 875 feet deep to the bedrock contact. Wells would need to be replaced regularly.	wells and 10 monitoring wells would be constructed down gradient from the pit. This number of wells may not be enough to ensure compliance with groundwater quality standards at the mixing zone boundary.	be used to direct pit water to the underground sump.
Maintenance of capture points	Settlement of the 100 feet of backfill could cause separation, buckling, or shearing of well casings. About 70 percent of settlement would occur during the backfill operation and 30 percent over a longer period after backfilling is complete.	Settlement effects on well casings would be more severe than under the No Pit Pond Alternative.	Wells would be constructed outside of the pit and would not be subject to backfill settling.	There would be no backfill to settle and no wells to damage. Rock fall from ceiling and walls of the underground workings could damage the dewatering system.
	Corrosion of the well casings, pumps, electrical components, monitoring equipment and pipelines from the acidic water in the backfill would cause periodic need for repair and replacement of dewatering system components.	Same as the No Pit Pond Alternative.	Short-term buffering by the aquifer and mixing with ambient groundwater would limit corrosion of pumps and screens, providing for longer pump life. After the buffering capacity of the aquifer is used up in a few tens of years, water quality would be similar to the No Pit Pond and Partial Pit Backfill With In-Pit Collection alternatives.	Corrosion would be similar to the No Pit Pond Alternative.
	Highwall raveling and sloughing could damage wellheads, monitoring equipment, power lines,	Not applicable.	Not applicable.	Similar to the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	and pipelines.			
	Pumping rates and lifts would not be a problem.	Lower pumping rates and higher lifts compared to the No Pit Pond Alternative would cause more pump failure and may cause the need to allow the water table to rebound for pumping efficiency.	Similar to the No Pit Pond Alternative.	Similar to the No Pit Pond Alternative.
	Not applicable.	Not applicable.	Not applicable.	Access to the underground would be needed. The agencies have assumed sloughing could bury the 4,550-foot elevation portal blocking access to the dewatering system needed for maintenance.
Storm water runon/runoff management				
Maintenance requirements (drainage channels off 2H:1V slopes)	Diversions would route water away from the pit. Settling of diversions constructed on unconsolidated materials and accumulations of sediment and material sloughed from above would impair diversions' function. Periodic cleaning and repairs would be needed. Eventually portions of the diversions would need to be reconstructed	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	completely.			
	Not applicable.	Diversions would be constructed on the 2H:1V slopes created by highwall reduction. Settling in the backfill could cause depressions where surface water could accumulate, infiltrate, and saturate the soil cover resulting in erosion on the face of the reclaimed slopes. Maintenance requirements for diversions would be the same as for the No Pit Pond Alternative, except there would be more diversions to maintain.	Maintenance requirements would be similar to the Partial Pit Backfill With In-Pit Collection Alternative. More settlement would occur due to saturation of the backfill.	Not applicable.
Soil cover				
Soil cover maintenance requirements (erosion, revegetation)	A 3-foot soil cover would be placed and revegetated on the pit floor, pit benches, and roads, totaling 53 acres.	A 3-foot soil cover would be placed and revegetated on the backfilled pit and reduced highwall, totaling 274 acres.	Similar to the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative except there would be 1.3 fewer acres to maintain in the pit.
	Eroded areas would need to be repaired, resoiled, and reseeded. Noxious weeds would have to be controlled.	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.
	The backfill surface would need to be regraded as the backfill settles. Rocks that ravel or slough from the highwall onto revegetated	Backfill would settle up to 150 feet. More backfill would have to be placed, graded, resoiled, and revegetated.	Backfill would settle up to 200 feet.	There would be no backfill needing cover maintenance.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	areas would need to be cleared. Depending on the volume of rock, regrading, resoiling, and reseeding of reclaimed surfaces may be needed.			
	Highwall seeps could saturate the soil cover with acidic water, contaminating soils and impairing revegetation success. The seep would have to be located and dewatered, contaminated soil would have to be replaced with clean soil, and the area would have to be revegetated.	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.
Water treatment				
Additional sludge management requirements	32 gpm of pit water would need treatment.	15 gpm of pit water would need treatment.	A maximum of 121 gpm of groundwater would be collected and treated trying to capture 95 percent of the 16 gpm of pit discharge.	Same as No Pit Pond Alternative.
	The sludge management requirements would be similar to or less than estimated in the 1997 Draft EIS.	Weathering would continue to produce oxidation byproducts in the unsaturated backfill. Pumping would limit saturation of the backfill and impacts from jarosite dissolution. More sludge would be produced per gallon of treated water than under the No Pit Pond Alternative,	Weathering would continue to produce oxidation byproducts in the unsaturated backfill. Jarosite in the saturated portion of the backfill would prevent reducing conditions from developing and allow further production of acid. Metals would be released during the dissolution of jarosite. The flow	The agencies have assumed that the water produced in the underground workings would be comparable to the water quality in the No Pit Pond Alternative. Because there would be no backfill, jarosite, adsorbed metals, and other oxidation byproducts would remain relatively immobile in

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
		but less water would be treated, so the sludge management requirements would be similar or less.	from the unsaturated portion of the backfill above the water table would contribute low pH water with high metals concentrations to the pit discharge for hundreds of years. There is limited natural attenuation capacity along the primary and secondary flow paths from the pit. The sludge management requirements would be about the same as the Partial Pit Backfill With In-Pit Collection Alternative because the chemical mass would be about the same.	the waste rock dump complex. There would be minimal additional sludge.
Additional operating requirements	There would be no additional water treatment operating requirements. The water treatment system in the SEIS is the same as that evaluated in the 1997 Draft EIS, and there would be less pit water to treat.	Same as the No Pit Pond Alternative.	The water treatment plant could require additional operating cost due to the increased water quantity treated under this alternative.	Same as the No Pit Pond Alternative.
Flexibility for future improvements				
Potential for utilization of new technologies	New technology, such as in situ water treatment, would be easier to apply in the less than 600,000 cubic yards of pit backfill and raveled and sloughed highwall rock under the No Pit Pond Alternative than it would be in the larger	New technology, such as in situ water treatment, would be harder to apply in 47 million cubic yards of pit backfill than under the No Pit Pond Alternative. Because of the problems with maintaining wells in acidic waste rock in the deeper	Similar to the Partial Pit Backfill With In-Pit Collection Alternative, except that in-situ water treatment would be more difficult because of the lack of wells in the backfill. If treatment were attempted outside of the pit, a dispersed plume may be more challenging to track,	New technology, such as in situ water treatment, would be easier to apply in the open water of an underground sump than in backfill.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	volumes of backfill under the partial pit backfill alternatives.	backfill, this alternative offers less potential for utilization of new technologies. It would be harder to redesign the dewatering system in up to 875 feet of backfill.	contain, and treat in-situ.	
Environmental Issues				
Impacts to groundwater quality and quantity				
Risk of impacts to groundwater quality and quantity in permit area	The pit would be maintained as a hydrologic sink, and 32 gpm of pit water would be collected and treated before being discharged. No impacts to groundwater quality from pit outflows are expected. The groundwater level around the pit would be permanently drawn down. This would result in minor reductions in the flows of springs that are hydrologically connected to the pit.	Same as the No Pit Pond Alternative, except 15 gpm would be collected and treated. Same as the No Pit Pond Alternative.	The pit would not be a hydrologic sink. Groundwater capture efficiency of 95 percent or greater of the 16 gpm of pit discharge would be required to meet water quality standards in the Jefferson River alluvial aquifer. This may not be achievable. The groundwater level around the pit would rebound so that the flows of springs that are hydrologically connected to the pit could be increased. Because of the higher pit groundwater elevation, ARD water from the pit could move along secondary flow paths in the bedrock and Bozeman Group aquifers where it is more	Same as the No Pit Pond Alternative, except 32 gpm would be pumped from the underground sump and treated. Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
			difficult to detect and collect. Groundwater quality would likely be degraded up gradient of the collection wells where groundwater is already impacted by ARD from natural mineralization and may eventually be impacted from a small portion of the East Waste Rock Dump Complex. The potential for creating new springs or affecting water quality of existing springs is higher than under the other alternatives.	
Risk of violation of groundwater standards at permit boundary and impacts to beneficial uses of the Jefferson River alluvial aquifer	Groundwater quality standards would be met at the permit boundary. Beneficial uses of the Jefferson River alluvial aquifer would not be affected.	Same as the No Pit Pond Alternative.	Groundwater quality standards would be met at the permit boundary with 95 percent or greater capture efficiency, and beneficial uses of the Jefferson River alluvial aquifer would not be affected. This may not be achievable. The current groundwater classification would be unchanged. With a lesser capture efficiency, groundwater quality standards for copper and nickel would be exceeded at the permit boundary and within the Jefferson River alluvial aquifer. DEQ would have to review the mixing zone.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Impacts to surface water quality and quantity				
Impacts to springs, wetlands	The groundwater level around the pit would be permanently drawn down resulting in minor reductions in the flows of springs that are hydrologically connected to the pit.	Same as the No Pit Pond Alternative.	The groundwater level around the pit would rebound so that the flows of springs that are hydrologically connected to the pit would remain the same or increase. New springs or seeps could be created that would be impacted by ARD from the pit. Discharges of ARD at existing springs around the pit area could increase.	Same as the No Pit Pond Alternative.
Risk of violation of surface water standards and impacts to beneficial uses of the Jefferson River and Slough	There would be no pit discharge. There would be no risk of violation of surface water standards and impacts to beneficial uses in the Jefferson River and Slough.	Same as the No Pit Pond Alternative.	The risk of contaminants reaching the Jefferson River or Slough and affecting surface water quality and beneficial uses is greater than for alternatives that maintain the pit as a hydrologic sink. Ninety-five percent groundwater capture efficiency would be needed to prevent exceeding groundwater quality standards after mixing with groundwater in the Jefferson River alluvial aquifer. High capture efficiencies may not be achievable. Control of pit seepage along secondary pathways may be difficult. There is little attenuation capacity in the Tertiary debris flow/colluvial aquifer.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Reclamation plan changes				
Surface disturbance	No new pit disturbance.	56 acres of new pit disturbance.	Same as the Partial Pit Backfill With In-Pit Collection Alternative, except 2 additional acres would be disturbed for downgradient wells.	Same as the No Pit Pond Alternative.
Hazards to wildlife	There would be no additional hazards to wildlife.	There would be fewer hazards to wildlife than under the No Pit Pond Alternative because the highwall would be eliminated.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.
Total remaining unrevegetated acres	158 acres	0 acres	0 acres	159 acres
Socioeconomic Issues				
Safety				
Risk to workers (reclamation and construction)	The safety risk to reclamation workers would be increased while backfill is being hauled down the steep roads into the pit because of the potential for truck accidents.	The safety risk to reclamation workers would be the same as under the No Pit Pond Alternative while 100 feet of crusher reject is being hauled down the steep roads into the pit. The rest of the backfilling would be by end dumping waste rock from the pit rim, a standard method used during mining that has less risk than hauling loaded trucks to the bottom of the pit. Cast blasting and dozing to reduce the pit highwall would present risks to workers.	Similar to the Partial Pit Backfill With In-Pit Collection except separate placement of crusher reject in the bottom of the pit would not be required.	Less than the No Pit Pond Alternative. Backfill would not be hauled into the pit.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	Workers would be below a highwall of up to 1,875 feet high with the risk of injury from rock falls.	Workers installing, operating, and maintaining the dewatering system would not be working below a highwall and would not be at risk of injury from rock falls.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Workers would be exposed to rock falls from the walls and ceiling of the underground workings as well as from the highwall. Overall risk would be less than the No Pit Pond Alternative.
Risk to workers (long-term maintenance)	Workers in the pit would be exposed to pit highwall raveling and sloughing. Long-term access would be needed to the pit bottom for monitoring and maintenance of the pit haul road, 5,700-foot-elevation pit safety bench, and the dewatering system.	Workers would not be exposed to pit highwall raveling and sloughing. Long-term access to the pit bottom would not be required. The risk to worker safety in this alternative would be less than the No Pit Pond Alternative and would be similar to the risk of work currently conducted on the waste rock dump complexes.	Similar to the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative, except workers would be exposed to rock falls from the walls and ceiling of the underground workings as well as from the highwall. Overall risk would be less than the No Pit Pond Alternative.
Risk to public safety	Access restrictions on general public use would be maintained and would consist of signs, berms, and fencing around the pit area, but there would still be a risk to public safety from the pit highwall.	Same as the No Pit Pond Alternative except and there would be no risk to public safety from the pit highwall.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.
Mining employment				
Potential employment from mining Stage 5B	750 person years	750 person years. Premature closure would reduce this by 150 person years per year.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Reclamation employment				
Reclamation employment opportunities	123 person years	308 person years	308 person years	124 person years
Revenue from taxes				
Potential tax revenues from mining Stage 5B	$8,087,000	Same as the No Pit Pond Alternative, except premature closure would reduce this to $60,000.	Same as the No Pit Pond Alternative, except premature closure would reduce this to $60,000.	$8,087,000
Potential tax revenues from pit backfill	$319,500	$806,000	$911,000	$322,000
Mineral reserves and resources				
Access to future mineral reserves/ Resources	If the pit were to be enlarged for additional mining in the future, it would take 1.5 months to remove the 600,000 cubic yards of backfill, soil, and highwall rock. Time is based on the 2002 mining rate of 405,000 cubic yards per month. The pit would have to be dewatered before it could be enlarged. The additional time required to dewater the pit would be minimal.	If the pit were to be enlarged for additional mining in the future, it could take 116 months to remove the 47 million cubic yards of backfill and soil, though it would likely take less than that. Time is based on the 2002 mining rate of 405,000 cubic yards per month. The pit would have to be dewatered. The additional time required to dewater the pit would be the same as the No Pit Pond Alternative.	Same as the Partial Pit Backfill With In-Pit Collection Alternative. Because the water table would rebound, more of the backfill would have to be dewatered as mining proceeded. The time required to dewater the pit would be longer than the Partial Pit Backfill With In-Pit Collection Alternative.	If the pit were to be enlarged for additional mining in the future, it would take 0.5 month to remove the 200,000 cubic yards of highwall rock and soil. Time is based on the 2002 mining rate of 405,000 cubic yards per month. Similar to the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Land use after mining				
Suitability of land use after mining	The land use after mining would be wildlife habitat. About 60 acres would be revegetated. About 158 acres of mule deer habitat would be lost. Limited raptor and bat habitat would be developed in the upper highwall.	The land use after mining would be wildlife habitat. About 272 acres would be revegetated. Up to 2 acres of habitat would be lost for access roads. Raptor and bat habitat would not be developed.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.
Aesthetics				
Visual contrast with adjacent lands	Portions of the highwalls and benches would remain visible. Overall visual contrasts would be reduced to a level where they are noticeable but not dominant in the landscape, following successful reclamation and revegetation. Landscape modifications would be consistent with the suggested VRM Class III rating for the area.	The reclaimed 2H:1V slopes covering the pit highwall and the reclaimed slopes of the waste rock dump complexes would still be visible, but the overall contrasts would be reduced under this alternative.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.
Potential future burden				
Potential future burden on society	The consequence of failure of this alternative would be creation of a pit pond below the 5,050-foot elevation. No impacts to groundwater and minimal impacts to springs would occur.	The consequence of failure of this alternative would be uncontrolled discharges of ARD-impacted groundwater from the backfilled pit, which could adversely impact springs and beneficial uses of the Jefferson River alluvial aquifer.	Same as Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Potential for future liabilities for GSM	No water would leave the pit. If the dewatering system failed, it could be re-established on the regraded pit bottom through 200 feet of backfill and sloughed highwall rock more easily than through up to 875 feet of backfill. Continued safe access to the dewatering system for operation and maintenance would be more difficult than the partial pit backfill alternatives because of highwall rock raveling and sloughing onto safety benches and access roads. Removing water from 100 feet of backfill would not be a problem. Dewatering system components would fail regularly from backfill settling and corrosion.	No water would leave the pit. If the dewatering system failed, it could be re-established by drilling new wells. Drilling and maintaining wells in up to 875 feet of backfill would be problematic. Safe access to the dewatering system for operation and maintenance would not be a problem because there would be no highwall. Removing water from up to 875 feet of backfill would be difficult. Dewatering system components would fail more often than under the No Pit Pond Alternative.	The potential for water quality degradation outside of the pit would be increased. About 16 gpm of untreated water would escape the pit. If the dewatering system failed to capture 95 percent of the groundwater, groundwater standards for some constituents would be exceeded at the edge of the mixing zone. The agencies assume the quality of the water collected down gradient of the pit would be partially attenuated and mixed with regional groundwater, but 95 percent capture may not be achievable. Dewatering system components would not fail as regularly due to settling and corrosion.	No water would leave the pit. Removing water from the underground sump would be easier than pumping out of backfill. If the dewatering system failed, it could be re-established more easily than under the partial pit backfill alternatives. Continued safe access to the dewatering system for operation and maintenance because of wall and ceiling rock sloughing in the underground workings would be less risky than the No Pit Pond Alternative. Dewatering system components would not fail as regularly due to corrosion.
Project Economics Issues				
Costs				
Reclamation costs	$1,168,000	$55,355,000	$55,357,000	$1,260,000

2.9 PREFERRED ALTERNATIVE

The rules and regulations implementing MEPA and NEPA (ARM 17.4.617 and 40 CFR 1502.14, respectively) require that the agencies indicate a preferred alternative, if one has been identified. Stating a preference at this time is not a final decision. The preferred alternative could change in response to public comment on the Draft SEIS, new information that becomes available, or new analysis that might be needed in preparing the Final SEIS. The preferred alternative at this time is the Underground Sump Alternative with visual mitigations described in Section 4.8.3.2.

2.9.1 Rationale for Selection

Under all alternatives, no highwall failure that would be a threat to public safety or the environment would occur and some wildlife habitat would be provided. However, only the Underground Sump and No Pit Pond Alternatives provide adequate assurance that pollution of the Jefferson River alluvial aquifer in violation of water quality laws will not occur. These alternatives would provide complete control of pit seepage through evaporation and collection. This would eliminate the possibility of contaminated water passing the mixing zone boundary and reaching the Jefferson River alluvial aquifer, thus violating the Water Quality Act. Complete control of pit seepage cannot be guaranteed under the other alternatives because of the problems associated with drilling and operating wells in the 875 feet of reactive backfill and with effectively capturing seepage in or down gradient of the pit.

With the imposition of the visual mitigations described in Section 4.8.3.2, the Underground Sump and No Pit Pond Alternatives also mitigate post reclamation visual contrasts between the pit and adjacent lands.

The Underground Sump Alternative would pose less risk to workers monitoring and operating the water capture system from rock raveling from the highwall than would the No Pit Pond Alternative. Under the No Pit Pond Alternative, the workers would perform these functions while exposed to the highwall. Under the Underground Sump Alternative, much of the work would be performed underground. In addition, the Underground Sump Alternative would require less maintenance than the No Pit Pond Alternative because it would not be susceptible to damage from rock raveling from the highwall.

The Bureau of Land Management is mandated by the Federal Land Policy and Management Act (PL 94-579) and subsequent 43 CFR 3809 surface management regulations to manage federal lands so as to avoid unnecessary or undue degradation of the federal lands. The preferred alternative avoids unnecessary or undue degradation of the land by maximizing the amount of mine impacted water collected and treated, limiting the potential for mine impacted water to escape collection, and limiting the potential for water quality violations at the mine's permit boundary.

Chapter 3

Affected Environment

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Chapter 3

Affected Environment

3.1 INTRODUCTION

The Affected Environment was described in the 1997 Draft EIS, Chapter III. This chapter updates the existing resource conditions at or near GSM that would be affected by the pit reclamation alternatives. Resources that would not be affected by the partial pit backfill alternatives are not discussed in detail. These resources are vegetation, aquatics, fisheries, noise, and air quality.

3.2 GEOLOGY AND GEOTECHNICAL

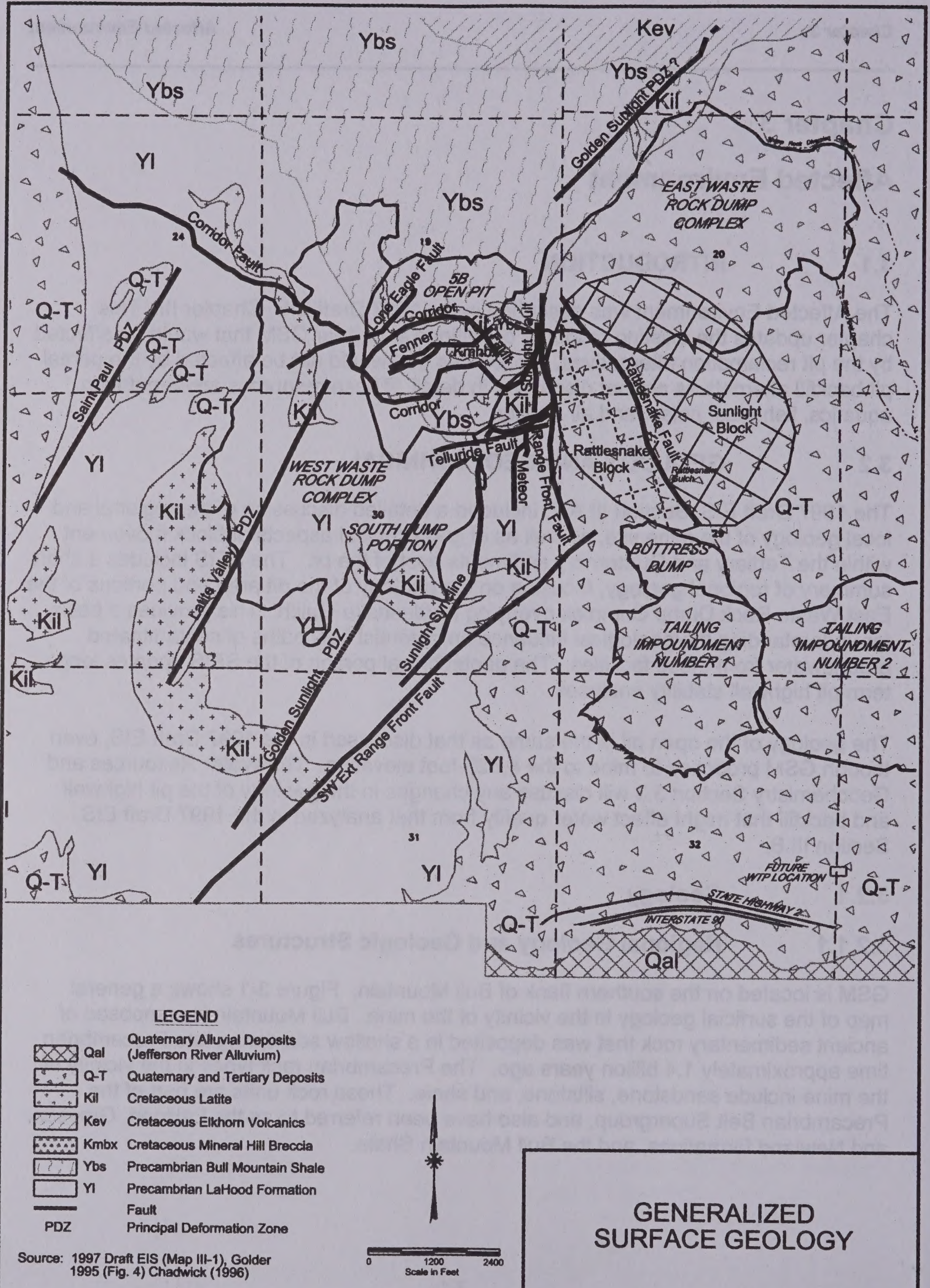
The 1997 Draft EIS, Section III.A.2, included a detailed discussion of the regional and local geology of the mine site, as well as of geotechnical aspects of block movement within the Tertiary and Quaternary sediments east of the pit. The SEIS includes a short summary of regional geology, focusing on the geology of the pit area and portions of the East Waste Rock Dump Complex overlying Rattlesnake Gulch. This provides a basis for understanding the geological influence on potential flow paths of contaminated groundwater from these facilities. The geotechnical portion of the SEIS updates long-term pit highwall stability analyses.

The geology of the open pit is the same as that discussed in the 1997 Draft EIS, even though GSM proposes to mine to the 4,525-foot elevation. The Water Resources and Geochemistry Section 3.3 will discuss any changes in the geology of the pit highwall and backfill that might affect water quality from that analyzed in the 1997 Draft EIS, Section III.B.

3.2.1 Geology

3.2.1.1 Regional Geology and Geologic Structures

GSM is located on the southern flank of Bull Mountain. Figure 3-1 shows a general map of the surficial geology in the vicinity of the mine. Bull Mountain is composed of ancient sedimentary rock that was deposited in a shallow sea during late Precambrian time approximately 1.4 billion years ago. The Precambrian rock types in the vicinity of the mine include sandstone, siltstone, and shale. These rock units are part of the Precambrian Belt Supergroup, and also have been referred to as the LaHood, Greyson, and Newland formations, and the Bull Mountain Shale.


Kev
Ybs
Golden Sunlight PDZ ?
Kil
Yl
Corridor Fault
24
19
Lone Eagle Fault
5B OPEN PIT
Corridor
Fenner
Kmbbx
Sunlight Fault
EAST WASTE ROCK DUMP COMPLEX
20
Q-T
Saint Paul PDZ
Corridor
Telluride Fault
Range Front Fault
Meteor
Rattlesnake Fault
Sunlight Block
Rattlesnake Block
Rattlesnake Gulch
WEST WASTE ROCK DUMP COMPLEX
30
SOUTH DUMP PORTION
Latite Valley PDZ
Golden Sunlight PDZ
Sunlight Syncline
SW Ext Range Front Fault
29
BUTTRESS DUMP
TAILING IMPOUNDMENT NUMBER 1
TAILING IMPOUNDMENT NUMBER 2
31
32
FUTURE WTP LOCATION
STATE HIGHWAY 2
INTERSTATE 90
Qal
LEGEND
Qal Quaternary Alluvial Deposits (Jefferson River Alluvium)
Q-T Quaternary and Tertiary Deposits
Kil Cretaceous Latite
Kev Cretaceous Elkhorn Volcanics
Kmbx Cretaceous Mineral Hill Breccia
Ybs Precambrian Bull Mountain Shale
Yl Precambrian LaHood Formation
Fault
PDZ Principal Deformation Zone
0
1200
2400
Scale in Feet

Source: 1997 Draft EIS (Map III-1), Golder 1995 (Fig. 4) Chadwick (1996)

Figure 3-1 SurfaceGeology.dwg

GENERALIZED SURFACE GEOLOGY

FIGURE 3-1

A period of mountain building or tectonic activity known as the Laramide Orogeny occurred approximately 70 to 85 million years ago during the Cretaceous. In the vicinity of the mine, regional compression of the earth's crust created folded blocks of rock followed by extension that resulted in high-angle (near vertical) faults. Precambrian rocks were penetrated by igneous intrusions and overlain by volcanic materials during this period. Cretaceous intrusive rocks in the vicinity of the mine include latite porphyry and numerous smaller lamprophyre dikes.

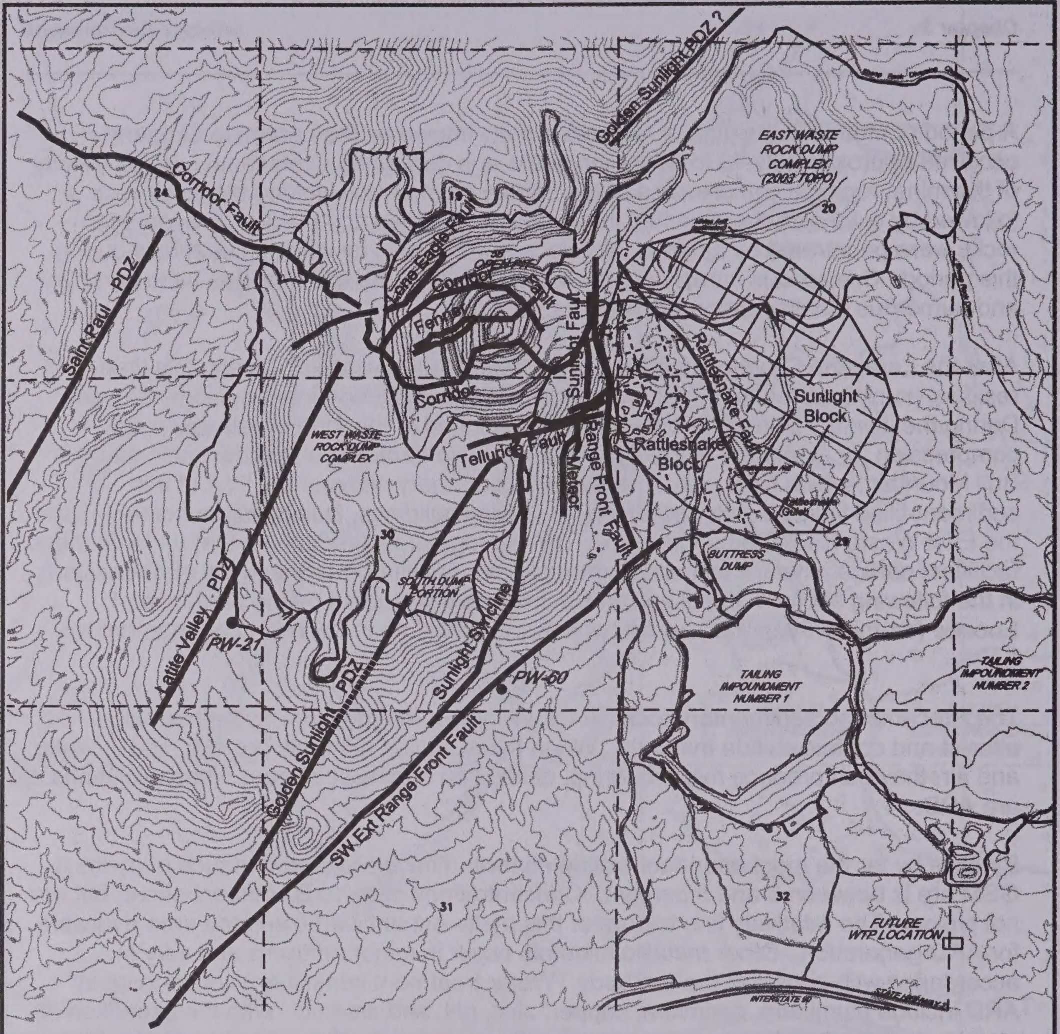
After the Laramide Orogeny, the landscape was relatively stable. During this time, residual (in-place) weathering of the rock surface was the dominant geologic process. During the Tertiary Period, tectonic activity continued in the form of relaxation of compression, or extension of the earth's crust. This formed the shallow basin east of Bull Mountain, which filled with Tertiary and Quaternary sediments. Part of this sediment-filled valley is now the site of the facility buildings, tailings impoundments, and the East Waste Rock Dump Complex. The geology of the sediments that underlie these facilities, particularly as it influences groundwater flow paths, is the focus of discussion in the following section. Local volcanic activity also is evident by the presence of Eocene (44-million-year-old) basalt, which is exposed near Tailings Impoundment No. 1.

The Precambrian sedimentary rocks in the vicinity of the mine are hydrothermally altered and contain sulfide minerals. When these sulfide minerals are exposed to water and air, they can produce metal-bearing, acidic iron sulfate solutions. These solutions are ARD.

Pyrite is by far the most abundant sulfide mineral. The average abundance of pyrite in GSM ore is between 3 and 5 percent. Concentrations of up to 20 percent occur, but are not typical. The relatively fine texture of this pyrite enhances the surface area available for ARD generation. Other metallic minerals occur in minor amounts and vary in accordance with zoning in the ore body. Water treatment constituents of concern in ARD include aluminum, cadmium, copper, zinc, pH, and arsenic. With the exception of aluminum, the other metals are predominantly associated with sulfide complexes and oxides.

3.2.1.2 Bull Mountain Geology and Geologic Structures

The open pit is centered on a breccia pipe in the Precambrian host rocks. The pit cuts through and is bounded by a highly complex series of east and northeast trending high-angle faults (Foster and Chadwick, 1990; Foster et al., 1993; Foster and Smith, 1995). The Range Front Fault is a major north-south high-angle slip fault that separates the Precambrian and Cretaceous rocks of the upland from the late Tertiary valley fill sediments. The Corridor Fault is a lens-shaped zone up to several hundred feet thick of low-angle faulting that dips approximately 16 degrees to the northeast (Hydrometrics, 1995). The major geologic structures in the vicinity of the pit are shown in Figure 3-2.


Golden Sunlight PDZ ?
EAST WASTE ROCK DUMP COMPLEX (2003 TOPO)
20
24
Corridor Fault
19
Lone Eagle Fault
JB OPEN PIT
Corridor
Fault
Fenner
Corridor
Sunlight Fault
Saint Paul PDZ
Rattlesnake Fault
Sunlight Block
Rattlesnake Block
Rattlesnake Gulch
WEST WASTE ROCK DUMP COMPLEX
Telluride Fault
Meteor
Range Front Fault
30
29
BUTTRESS DUMP
SOUTH DUMP PORTION
Latite Valley PDZ
PW-21
Sunlight Syncline
PW-60
TAILING IMPOUNDMENT NUMBER 1
TAILING IMPOUNDMENT NUMBER 2
Golden Sunlight PDZ
SW Ext Range Front Fault
31
32
FUTURE WTP LOCATION
INTERSTATE 90
STATE HIGHWAY 2

LEGEND

PDZ	Principal Deformation Zone
▬	Fault

NOTE: Refer to Figure 3-5
Spring and Monitoring Well Locations
for complete location of all wells.

0 1200 2400
Scale in Feet

MAJOR BEDROCK GEOLOGIC STRUCTURES IN THE VICINITY OF THE PIT

Figure 3-2 geostructures.dwg

FIGURE 3-2

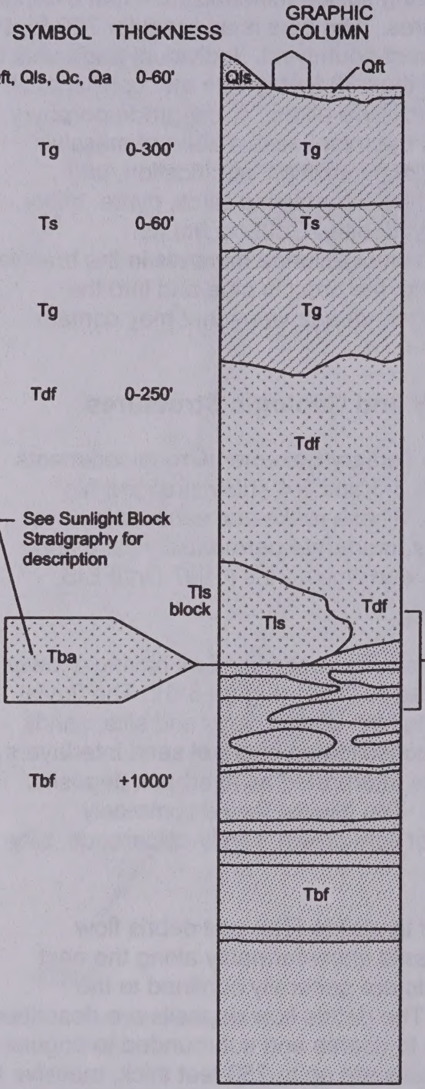
The breccia pipe contains disseminated gold-bearing sulfide mineralization that extends more than 100 feet into wallrock in silicified fractures. The pipe is an irregular 700-foot-diameter oval, which plunges 35 degrees to the west-southwest. Individual fragments in the breccia range from less than 1 inch to greater than 30 feet in size and consist of all local rock types except for the late intruding lamprophyre dikes. A low-grade porphyry molybdenum system is located in and adjacent to the mine, as is a zone of massive sulfides in Precambrian rocks. Alteration consists of pyritization, silicification, and decarbonization with an alteration mineral assemblage containing silica, pyrite, barite, sericite, chalcopyrite, galena, sphalerite, and molybdenite. Gold occurs as disseminated particles associated with pyrite and minor telluride minerals in the breccia matrix and surrounding rock. Superimposed across the breccia pipe and into the surrounding highwall rock are northeast trending gold-quartz veins that may contain pyrite, galena, sphalerite, and barite.

3.2.1.3 Tertiary/Quaternary Geology and Geologic Structures

The area east of Bull Mountain contains valley fill Tertiary Bozeman Group sediments up to 1,500 feet thick (Hanneman, 1990). Figures 3-3 and 3-4 show stratigraphic sections from two locations east of Bull Mountain. These rocks and sediments have diverse lithologies including low permeability clays, moderate permeability sandstone and conglomerate, and carbonate-bearing shales and limestones (1997 Draft EIS, Chapter III, Section A).

The Bozeman Group in the vicinity of the mine has been recognized as having a lower fluvial (stream deposits) facies (Tbf) and alluvial facies (Tba) (Figure 3-3). The fluvial facies generally consists of interbedded medium to high plastic clays and silts, sands and clayey sands. The fluvial facies contains unconsolidated channel sand interlayers, but the bulk of the unit consists of clays, which are interpreted as overbank deposits, exhibiting good lateral continuity (Golder, 1995a). The alluvial facies commonly contains less than 20 percent clay, and consists of light brown, lightly calcareous, silty sands and gravels.

Late Tertiary mass-wasting deposits consisting of landslide (Tls) and debris flow deposits (Tdf) overlie the Bozeman Group sediments unconformably along the east front of Bull Mountain. The mass-wasting deposits are generally confined to the Rattlesnake Block (Golder, 1995a) (Figure 3-3). The debris flow deposits are described as consisting of sandy and silty gravel that is fine to coarse and subrounded to angular, with cobbles and boulders. The debris flow deposits are up to 250 feet thick, massive to bedded, and unconsolidated to well cemented with iron oxide. Associated landslide deposits are composed of more or less intact blocks of latite and other pre-Tertiary bedrock blocks that may be up to 1,500 feet long and 200 feet thick.



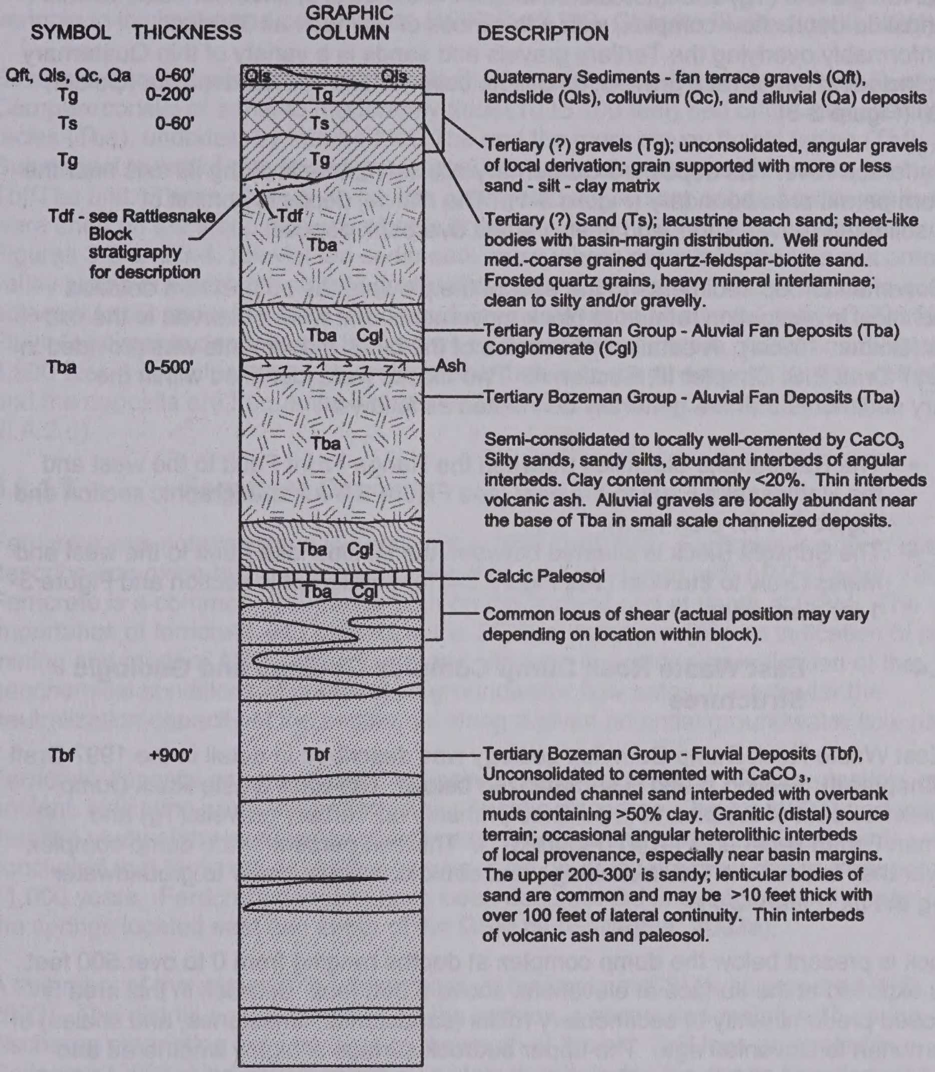
SYMBOL	THICKNESS	DESCRIPTION
Qft, Qls, Qc, Qa	0-60'	Quaternary Sediments - fan terrace gravels (Qft), landslide (Qls), colluvium (Qc), and alluvial (Qa) deposits
Tg	0-300'	Tertiary (?) gravels (Tg); unconsolidated, angular gravels of local derivation; grain supported with more or less sand - silt - clay matrix
Ts	0-60'	Tertiary (?) Sand (Ts); lacustrine beach sand; sheet-like bodies with basin-margin distribution. Well rounded med.-coarse grained quartz-feldspar-biotite sand. Frosted quartz grains, heavy mineral laminae; clean to silty and/or gravelly; unconsolidated.
Tg		
Tdf	0-250'	Tertiary debris flow and landslide deposits (Tdf/Tls) Clay-matrix supported sand to boulder size angular clasts. Massive to well bedded. Semi-consolidated to locally well-cemented with iron oxide. Landslide blocks up to 1500 feet in length, >200' thick.
		Common locus of shear (actual position may vary depending on location within block). Shear is related to Rattlesnake Block movement.
Tbf	+1000'	Tertiary Bozeman Group - Fluvial Facies (Tbf) Unconsolidated, subrounded channel sand interbedded with overbank muds containing >50% clay. Granitic (distal) source terrain; occasional angular heterolithic interbeds of local provenance, especially near basin margins. The upper 200-300' is sandy; lenticular bodies of sand are common and may be >10 feet thick with over 100 feet of lateral continuity. Thin interbeds of volcanic ash.

GEOLOGY: T.H. CHADWICK
SOURCE: GOLDER, 1995a

TYPICAL STRATIGRAPHIC COLUMN FOR RATTLESNAKE BLOCK

Figure 3-3 column.dwg

FIGURE 3-3


SYMBOL
THICKNESS
GRAPHIC COLUMN
DESCRIPTION
Qft, Qls, Qc, Qa
0-60'
Qls
Qls
Tg
0-200'
Tg
Ts
0-60'
Ts
Tg
Tg
Tdf - see Rattlesnake Block stratigraphy for description
Tdf
Tba
Tba Cgl
Ash
Tba
0-500'
Tba
Tba Cgl
Tba Cgl
Tbf
+900'
Tbf

Quaternary Sediments - fan terrace gravels (Qft), landslide (Qls), colluvium (Qc), and alluvial (Qa) deposits

Tertiary (?) gravels (Tg); unconsolidated, angular gravels of local derivation; grain supported with more or less sand - silt - clay matrix

Tertiary (?) Sand (Ts); lacustrine beach sand; sheet-like bodies with basin-margin distribution. Well rounded med.-coarse grained quartz-feldspar-biotite sand. Frosted quartz grains, heavy mineral interlaminae; clean to silty and/or gravelly.

Tertiary Bozeman Group - Aluvial Fan Deposits (Tba) Conglomerate (Cgl)

Ash

Tertiary Bozeman Group - Aluvial Fan Deposits (Tba)

Semi-consolidated to locally well-cemented by $CaCO_3$ Silty sands, sandy silts, abundant interbeds of angular interbeds. Clay content commonly <20%. Thin interbeds volcanic ash. Alluvial gravels are locally abundant near the base of Tba in small scale channelized deposits.

Calcic Paleosol

Common locus of shear (actual position may vary depending on location within block).

Tertiary Bozeman Group - Fluvial Deposits (Tbf), Unconsolidated to cemented with $CaCO_3$, subrounded channel sand interbeded with overbank muds containing >50% clay. Granitic (distal) source terrain; occasional angular heterolithic interbeds of local provenance, especially near basin margins. The upper 200-300' is sandy; lenticular bodies of sand are common and may be >10 feet thick with over 100 feet of lateral continuity. Thin interbeds of volcanic ash and paleosol.

GEOLOGY: T.H. CHADWICK
SOURCE: GOLDER, 1995a

TYPICAL
STRATIGRAPHIC COLUMN
FOR SUNLIGHT BLOCK

Figure 3-4 column.dwg

FIGURE 3-4

Alluvial fan gravels (Tg) and intercalated lacustrine sands (Ts) unconformably overlie the landslide-debris flow complex, with a thickness of as much as 360 feet. Disconformably overlying the Tertiary gravels and sands is a variety of thin Quaternary cover, including fan-terrace gravels, landslide, colluvial and alluvial deposits (Golder, 1995a) (Figure 3-3).

The Jefferson River has deposited Quaternary alluvial materials along its axis near the southern permit area boundary (Figure 3-1). The alluvial deposits consist of unconsolidated gravel, sand, and finer-grained overbank deposits.

The Bozeman Group sediments to the east of the pit were the subject of a detailed geotechnical investigation related to block movements that were observed in the mid-1990s (Golder, 1995a). A detailed discussion of the block movements was provided in the 1997 Draft EIS, Chapter III, Section A. Two blocks were identified within the Tertiary sediments that are generally delineated as follows:

- The Rattlesnake Block lies between the Range Front Fault to the west and the Rattlesnake Fault to the east (see Figure 3-3 for stratigraphic section and Figure 3-1 for plan view).
- The Sunlight Block is situated between the Rattlesnake Fault to the west and Midas Draw to the east (see Figure 3-4 for stratigraphic section and Figure 3-1 for plan view).

3.2.1.4 East Waste Rock Dump Complex Geology and Geologic Structures

The East Waste Rock Dump Complex geology was described in detail in the 1997 Draft EIS, Chapter III, Section A and is summarized below. The East Waste Rock Dump Complex lies east of the pit and is perched primarily on Tertiary gravels (Tg) and Bozeman Group sediments (Tba) (Figure 3-1). Thirteen percent of the dump complex lies over the Rattlesnake Gulch drainage and could contribute water to groundwater leaving the pit (Figure 3-7).

Bedrock is present below the dump complex at depths ranging from 0 to over 500 feet and is exposed at the surface at elevations above 5,050 feet. Bedrock in this area is composed predominantly of sedimentary rocks (sandstones, limestones, and shales) of Precambrian to Devonian age. The upper bedrock surface is highly weathered and altered to clay in some places. The sedimentary bedrock has been fractured, faulted, and folded, resulting in local variations in bedding orientation. The prevailing strikes of principal faults are north-northeasterly, and their dips are about 60 degrees to the east.

The East Waste Rock Dump Complex site is situated near the northern margin of the valley-fill deposits, with the bedrock surface generally deepening and widening towards the south. Immediately overlying the bedrock surface under much of the East Waste Rock Dump Complex area is a thin layer (0 to 40 feet) of Tertiary gravels, sands, and clays (Tcgl) (also known as the Red Hill Conglomerate) (Figure 3-4). This unit is highly variable in thickness and composition (1997 Draft EIS, Chapter III, Section III.A.2.d).

Bozeman Group sediments that underlie the footprint of the East Waste Rock Dump Complex consist of a thin to moderately thick (10 to 100 feet) bed of the silty alluvial fan facies (Tba), underlain by interbedded Tba and the more clayey fluvial facies (Tbf). Substantial layers of gravel and gravel/clay interbeds also are present within the Tbf/Tba unit. These gravelly layers are interpreted as Tertiary debris flow deposits that were shed off the steep mountain fronts in mass wasting events, as indicated on Figures 3-3 and 3-4. Alluvial fan sediments occur where mountain streams exit onto valley plains or where the stream gradient suddenly decreases. These deposits occur adjacent to the mountain front up to a maximum elevation of approximately 5,200 feet. Fluvial sediments deposited in the valleys by flowing streams are predominant below 4,900 feet in the mine area. The relationship between these deposits is often complex and the deposits are frequently interbedded (1997 Draft EIS, Chapter III, Section III.A.2.d).

3.2.1.5 Ferricrete Deposits

Ferricrete was not discussed in detail in the 1997 Draft EIS. Ferricrete is a term used to describe iron oxide/hydroxide precipitates that are associated with ARD (Taylor, 1997). Ferricrete is a common occurrence both on the surface and at depth at GSM. The importance of ferricrete with respect to the SEIS is that it provides an indication of pre-mining and modern ARD production at the site, and it provides an indication of the geochemical conditions of potential pit groundwater flow paths, in particular the neutralization capacity of the sediments along a given potential groundwater flow path.

Ferricrete deposits can be modern, indicating recent or on going ARD production, or ancient, indicating prehistoric production of acidic discharge. Taylor (1997) performed a detailed study of the occurrence of ferricrete at or near the surface at GSM, and concluded that ferricrete deposition has been an on-going process, dating back some 11,000 years. Ferricrete deposits have been documented in association with many of the springs located east and south of the GSM pit (Gallagher, 2003a).

A summary of the documented occurrence of ferricrete at GSM was prepared (HSI, 2003). The distribution of ferricrete on the surface is associated mainly with spring discharge emanating from bedrock to the south of the pit. Drill logs presented in Gallagher (2003a) indicate ferricrete is widely distributed in the debris flow deposits between the east flank of Bull Mountain and Rattlesnake Gulch (HSI, 2003). Historic ferricrete deposits do not appear to occur to the east of Rattlesnake Gulch. However, modern ferricrete is likely being created within the East Waste Rock Dump Complex (Taylor, 1997).

Ferricrete deposits have also been documented at depth along the eastern flank of Bull Mountain in monitoring wells, including PW-8, PW-12, PW-47, PW-63 and PW-64 (Figure 3-5), as well as in a gold-bearing hematite deposit that extends down the Rattlesnake Gulch drainage from just east of the pit down to Rattlesnake Spring. These deposits may be indicative of ancient surficial ferricrete deposits that were formed due to ARD emanating from the mineralized bedrock to the west, or they may have resulted from mass-wasting transport of mineralized Tertiary debris flow and landslide rock onto the east flank of Bull Mountain (URS, 2001).

3.2.2 Geotechnical

3.2.2.1 Ground Movements

Ground movements in the mine area are categorized according to three distinct mechanisms of instability:

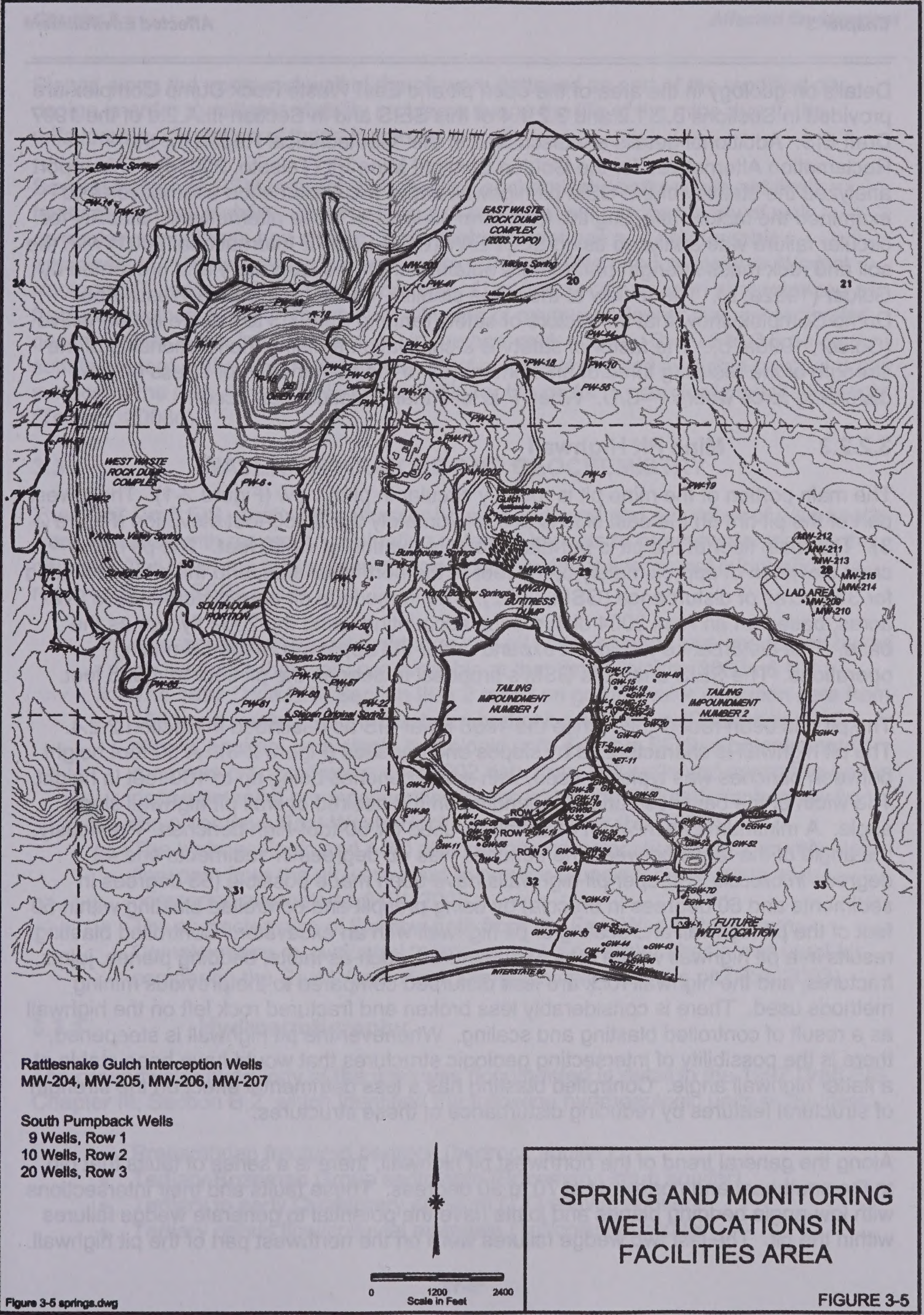
- Sliding of materials off Bull Mountain on steep, near-surface shear planes;
- Relatively slow movement of massive blocks of valley fill sediments along deep, low-angle shear surfaces; and,
- Sliding of fault-bounded blocks of bedrock along shear planes due to loss of lateral support.

The first type of ground movement is referred to as a landslide. The second and third types are called earth block slips or landslips (Golder, 1995a). The first two types of ground movement are the result of long-term natural geologic processes. The third type of movement may be caused by human activities, such as pit excavation. All three types can be exacerbated by human activities.

Known features that have moved recently are described in Section III.A.2.b of the 1997 Draft EIS. No ground movements have been documented outside of the pit since the 1998 Final EIS was prepared.

3.2.2.2 Faulting and Seismicity

GSM is located in a region known as the Intermountain Seismic Belt (ISB) (Smith and Sbar, 1974; Stickney and Bartholomew, 1987). The ISB is sharply defined in this area by historic seismicity along about a 50-mile-wide, northerly trending zone. Ninety-five percent of the earthquake activity in the region occurs within this zone. Most of the historically measured earthquakes in the vicinity of the site are very small and are referred to as micro-earthquakes.


Beaver Springs
PW-14
PW-13
EAST WASTE ROCK DUMP COMPLEX (2003 TOPO)
MW-203
Miles Spring
PW-47
19
20
21
24
PW-49
R-18
PW-9
PW-44
PW-53
PW-57
PW-18
PW-10
PW-62
PW-64
PW-52
PW-12
PW-56
PW-8
PW-11
OPEN PIT
WEST WASTE ROCK DUMP COMPLEX
PW-6
MW202
PW-5
PW-19
Rattlesnake Gulch
Rattlesnake Spring
Antoine Valley Spring
Sunlight Spring
30
Bunkhouse Springs
MW200
GW-15
29
MW-212
MW-211
MW-213
28
MW-215
MW-214
North Borrow Springs
BUTTRESS DUMP
LAD AREA
MW-209
MW-210
SOUTH DUMP PORTION
PW-50
PW-58
Stepan Spring
PW-17
PW-67
PW-60
PW-61
PW-22
Stepan Original Spring
TAILING IMPOUNDMENT NUMBER 1
TAILING IMPOUNDMENT NUMBER 2
GW-17
GW-48
GW-47
ET-11
EGW-3
GW-21
GW-50
ROW 1
ROW 2
ROW 3
EGW-5
GW-52
EGW-1
EGW-8
31
32
33
GW-51
EGW-7D
FUTURE WTP LOCATION
GW-37
GW-33
GW-34
GW-44
GW-43
INTERSTATE 90
0
1200
2400
Scale in Feet

Rattlesnake Gulch Interception Wells
MW-204, MW-205, MW-206, MW-207

South Pumpback Wells
9 Wells, Row 1
10 Wells, Row 2
20 Wells, Row 3

SPRING AND MONITORING WELL LOCATIONS IN FACILITIES AREA

Figure 3-5 springs.dwg

FIGURE 3-5

Details on geology in the area of the open pit and East Waste Rock Dump Complex are provided in Sections 3.2.1.2 and 3.2.1.4 of this SEIS and in Section III.A.2.d of the 1997 Draft EIS. Additional details are discussed in the "Geotechnical Report for the Reclamation Alternatives for the Golden Sunlight Mine Pit (Telesto, 2003d). This report analyzed the stability of the GSM pit highwall under two reclamation alternatives and examined the factors affecting the long-term aspects of these alternatives. Stability for circular failure was analyzed using SLOPE/W (GEO-SLOPE International 2001) with the soil and rock mass strength parameters obtained from the laboratory and presented by Golder (1992a, b). The review of the slope stability results for the East Waste Rock Dump Complex show that the factors of safety ranging from 1.3 to 1.5 are conservative (Golder, 1995a, b). The factor of safety is a calculation defining the relationship of the strength of the resisting force of an element (C) to the demand (D) or stress on the disturbing force where F=C/D. When F is less than 1, failure can occur.

3.2.2.3 Mine Pit Highwall

The main portion of the mine pit is roughly circular in plan view (Figure 2-1). The lowest part of the pit rim on the east side is at approximately the 5,350-foot elevation (Figure 2-3). The main floor of the pit is permitted to an elevation of 4,650 feet. The pit has a crest elevation of approximately 6,400 feet at the northwest side, and the pit is permitted for 336 acres of disturbance (GSM, 2002). The immediate pit area disturbance is 218 acres, based on an April 2004 disturbance accounting using the 2002 flyover as the base. This disturbance would not expand under the approved Stage 5B mining operations. The SEIS analyzes GSM's proposal to deepen the pit floor to 4,525 feet.

The pit has been redesigned since the 1998 Final EIS as described in Section 2.2.4. The pit highwall is characterized by slopes and benches (Figure 2-3). A 50-foot height between benches was typically used, with some benches being up to 100 feet in height. The width of the benches varies, depending on the desired overall pit highwall slope angle. A minimum bench width of 22 feet is used for 50-foot-high benches. Previously, the angle of the faces between the benches was 45 degrees in sediments and 49 degrees in breccia. Steeper pit highwalls have been made possible (53 degrees in sediments and 60 degrees in breccia) by using presplit and controlled blasting within 50 feet of the pit highwall and scaling of pit highwall with an excavator. Controlled blasting results in a pit highwall where structural features, such as faults, bedding planes, joints, fractures, and the highwall rock are less disturbed compared to the previous mining methods used. There is considerably less broken and fractured rock left on the highwall as a result of controlled blasting and scaling. Whenever the pit highwall is steepened, there is the possibility of intersecting geologic structures that would have been stable at a flatter highwall angle. Controlled blasting has a less detrimental effect on the strength of structural features by reducing disturbance of these structures.

Along the general trend of the northwest pit highwall, there is a series of faults that dip to the southeast and northwest at 70 to 90 degrees. These faults and their intersections with low-angle bedding planes and joints have the potential to generate wedge failures within the pit. The last two wedge failures were on the northwest part of the pit highwall.

Slopes along the northwest wall of the pit were flattened as part of the modified pit design in order to mitigate stability problems during the life of the mine due to the unfavorable orientation of these features.

Several factors at GSM indicate that physical or chemical weathering is not likely a factor in highwall stability. The host breccia rock consists predominantly of well-cemented sandstones and shales. Both field observations and petrographic examination indicate that the host rocks are hard with little or no porosity or internal fracturing (Telesto, 2003d). The hydrology of the host rock has been characterized as fracture dominated, which means the diffusion of oxygen or flow of oxygenated water occurs largely in the fractures and not in the host rock matrix. The 0.5 to 2.0 percent sulfide content of the host rock has the effect of consuming any available oxygen at the surface of the rock, further limiting the ability for the rocks to chemically weather deeply (Telesto, 2003d).

3.3 WATER RESOURCES AND GEOCHEMISTRY

The 1997 Draft EIS, particularly Chapter IV, was reviewed and a number of data needs were identified with respect to evaluating potential impacts to groundwater leaving the pit area. The following tasks were completed to provide the technical information required for the SEIS:

- A re-analysis of the pit hydrology and pit water balance was conducted based on field data that were not available at that time (Telesto, 2003a & b).
- The 1997 Draft EIS, Section III.B.2 relied on groundwater elevation data from 1993 and treated the Precambrian bedrock and Tertiary/Quaternary (T/Q) alluvial aquifers as a single hydrologic unit. For this SEIS, a potentiometric map was prepared using only 2002 data from T/Q wells and springs to better define potential groundwater flow paths within the T/Q sediments away from the pit and the East Waste Rock Dump Complex (HSI, 2003).
- The hydrogeologic and ARD attenuation characteristics of the groundwater flow path from the pit were used to provide a basis for evaluating and comparing alternatives (HSI, 2003).
- The characteristics of the flow path from the East Waste Rock Dump Complex were re-evaluated to ensure that a consistent basis was used for comparing the East Waste Rock Dump Complex and the pit (HSI, 2003).

3.3.1 Hydrostratigraphy

The groundwater hydrology of the area was documented in detail in the 1997 Draft EIS, Chapter III, Section B.2, which identified the following hydrogeologic units or aquifers:

- Precambrian fractured bedrock (bedrock aquifer)
- Tertiary Bozeman Group sediments (Bozeman Group aquifer)
- Tertiary to early Quaternary alluvium (T/Q alluvial aquifer)
- Tertiary debris flow/colluvial materials (Tdf/colluvial aquifer)

- Jefferson River alluvium (Jefferson River alluvial aquifer)

3.3.1.1 Bedrock Aquifer

The fractured Precambrian bedrock is the primary hydrogeologic unit that occurs in the pit area and west of the Bull Mountain area (Figure 3-1). As described in Section 3.2.1, the bedrock consists of several different rock types.

Bull Mountain groundwater flow in the bedrock aquifer is controlled by secondary geologic features. The ability of an aquifer to transmit water is defined by its permeability, which is measured in units of length per unit time. The permeability of the bedrock aquifer is a function of the heterogeneous fracture porosity. Depending on the fracture width, spacing, abundance, and orientation, some fracture systems will transmit more water than others. Bedrock permeability varies on a local scale, but when examined on a regional scale, bedrock permeability can be characterized by an average or bulk permeability. Regional analyses yield bulk bedrock permeabilities with values on the order of $1x10^{-6}$ centimeters/second (cm/sec) to $1x10^{-7}$cm/sec, with generally lower values in deeper bedrock (1997 Draft EIS, Chapter III, Section B).

3.3.1.2 Bozeman Group Aquifer

The Bozeman Group aquifer is a hydrogeologic unit that occurs east and south of Bull Mountain where it overlies the bedrock unit. It is comprised of alternating and interfingering layers and lenses of sand, silt, and clay deposited in a fluvial (river or stream) environment. Inspection of drill cuttings has shown fine to coarse-grained sand intermixed within clay and thin sand and gravel lenses. The discrete layers of clay, silt, sand, and fine gravel within the Bozeman Group sediments are discontinuous due to the fluvial depositional environment. The frequency of occurrence of sand and gravel lenses suggests that these lenses are interconnected to some degree, controlling the primary permeability of the unit. The Bozeman Group sediments typically have a low bulk permeability on the order of $2.5x10^{-5}$ to $7x10^{-6}$ cm/sec due to the abundance of silt and clay, but they can locally exhibit relatively high permeability in sand and gravel layers and lenses (1997 Draft EIS, Chapter III, Section B.2.a).

3.3.1.3 Tertiary/Quaternary Alluvial Aquifer

The Tertiary/ Quaternary colluvium and alluvium were deposited on the Bozeman Group sediments. This unit consists of locally derived gravels in a silty sand matrix that also may include reworked Bozeman Group sediments and older Tertiary fan terrace deposits consisting of sand, gravel, and clay. Younger alluvial sand and gravel found in modern drainages in the area also are included with this unit, since they share similar textural characteristics with the older deposits. This unit is thickest adjacent to the East Waste Rock Dump Complex area on the east side of Bull Mountain and thins to the south and east. Aquifer tests of the Quaternary alluvium and colluvium indicate permeability in the range of $1x10^{-3}$ to $1x10^{-4}$ cm/sec, with localized values as high as $2x10^{-2}$ cm/sec (Hydrometrics, 1995 and SHB, 1981).

3.3.1.4 Tertiary Debris Flow/Colluvial Aquifer

This unit is present locally on the east side of Bull Mountain and is most important in Rattlesnake Gulch in terms of areal extent and saturated thickness. Geologic cross sections indicate that the unit comprises a relatively continuous series of channelized sediments that exist from just east of the open pit to the north end of Tailings Impoundment No. 1 (Golder, 1995a; HSI, 2003). Depending on location, the unit may be exposed at the surface or overlain by recent alluvium and colluvium. The hydraulic conductivity of the unit is estimated to range from 1×10^{-3} to 1×10^{-4} cm/sec (Golder, 1995a). Saturated thickness within the unit ranges from in excess of 100 feet beneath the mill site to tens of feet where the unit thins and is exposed at the surface. Saturated thickness within the unit has been reduced by the Rattlesnake Gulch groundwater interception wells, which currently produce approximately 50 gpm (HSI, 2003). This unit appears to convey the majority of groundwater flow in the Rattlesnake Block down Rattlesnake Gulch (Golder, 1995a).

3.3.1.5 Jefferson River Alluvial Aquifer

The Jefferson River alluvial aquifer is near the southern permit area boundary and consists of unconsolidated gravel, sand, and finer-grained overbank deposits (Figure 3-1). Saturated thickness of the aquifer within the permit boundary is estimated to be approximately 20 feet (SHB, 1986). The majority of inflow to the Jefferson River alluvial aquifer south of GSM is through-flow from the west. Relatively minor amounts are contributed from the T/Q alluvial aquifer and Tdf/colluvial aquifer at the mine site to the north (SHB, 1986). The Jefferson River alluvial aquifer is in direct contact with an alluvial channel that underlies Tailings Impoundment No. 1 to the north (SHB, 1985). The direction of groundwater flow in the Jefferson River alluvial aquifer is generally believed to be to the east (SHB, 1985). Hydraulic conductivity estimates for the Jefferson River alluvial aquifer are approximately 2×10^{-1} cm/sec (SHB, 1986). Pumping rates ranging from 10 to 300 gpm have been reported on drillers' logs filed with the Montana Department of Natural Resources and Conservation (DNRC) (SHB, 1987). Gentle groundwater gradients have been documented within the Jefferson River alluvial aquifer and are considered indicative of a highly permeable groundwater flow system (SHB, 1986).

3.3.2 Potentiometric Surface in the Tertiary/Quaternary Aquifer

A potentiometric map displays contours of equal elevation of the total hydraulic head and pressure in a particular aquifer with water table or groundwater elevations identified. These maps are routinely used to obtain directions of groundwater flow. In the 1997 Draft EIS, Chapter III, Section B.2.a, groundwater elevation data were used to develop a generalized regional potentiometric map of the mine area for late season 1993 conditions (Chapter III, Figure III-5).

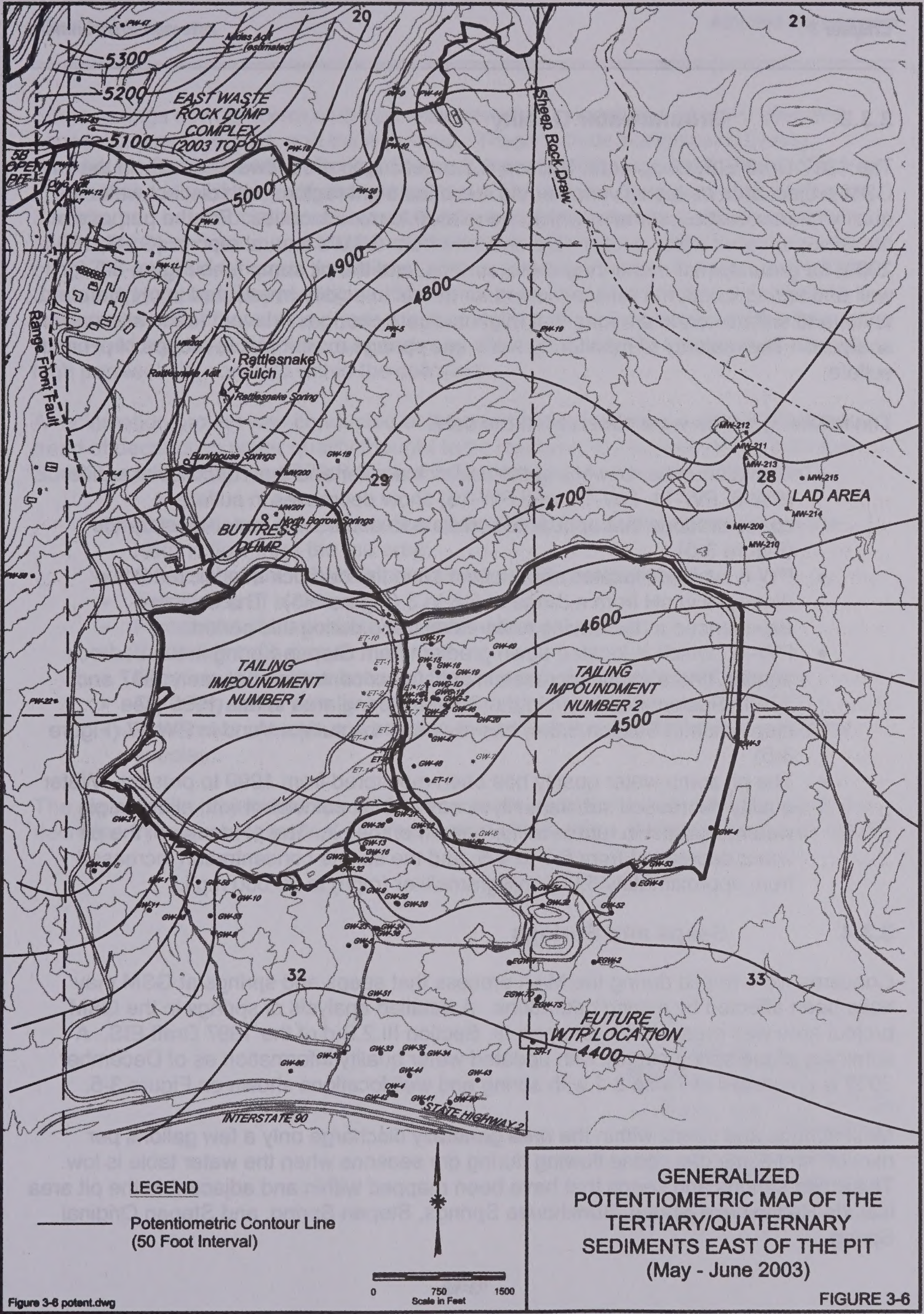
The new potentiometric map (Figure 3-6), which focuses on the Tertiary and Quaternary aquifer system, was constructed for the following reasons:

1. To characterize groundwater flow paths in the Tertiary and Quaternary sediments downgradient from the open pit and the East Waste Rock Dump Complex
2. To update the potentiometric map to current site conditions
3. Analyses in this document treat the bedrock aquifer and the Tertiary and Quaternary aquifer as separate hydrologic units

The new potentiometric map represents groundwater elevations from selected wells that are completed only in the Tertiary and Quaternary aquifer (Figure 3-6). Wells were selected for inclusion in the map based on the geologic map of GSM (GSM, 1996) and a review of well completion details (GSM annual reports). Some wells were eliminated from the potentiometric map because they were screened in a perched aquifer, for example, within the tailings impoundments, or very deep in the Bozeman Group sediments, which gives a relatively low head, or they are near the land application disposal (LAD) infiltration pond (HSI, 2003).

In the area between Tailings Impoundment No. 1 and the Jefferson River alluvial aquifer, a saturated sand and gravel channel is incised into the Bozeman Group aquifer (Hydrometrics, 1994; Keats, 2001). Where this sand and gravel aquifer was hydrologically continuous with the upgradient Tdf/colluvial aquifer (Golder, 1995a), data from wells in the Quaternary deposits were utilized so that the uppermost and potentially the most rapid groundwater flow path was addressed.

The Jefferson River alluvial aquifer abuts the T/Q alluvial aquifer on the GSM property several hundred feet north of I-90. Studies by Hydrometrics (1994) and Keats (2001-2002) indicate that these aquifers are hydrologically connected. Therefore, the potentiometric map included data from wells completed in the Jefferson River alluvial aquifer, including the southernmost GSM monitoring wells along the permit boundary and private water wells in the valley just south of the boundary. Elevations of the private wells were estimated from the United States Geological Survey (USGS) topographic map and adjusted (+91.4 feet) to GSM datum.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33
5300
5200
5100
5000
4900
4800
4700
4600
4500
4400
EAST WASTE ROCK DUMP COMPLEX (2003 TOPO)
5B OPEN PIT
Midas Adit (estimated)
Sheep Rock Draw
Range Front Fault
Rattlesnake Gulch
Rattlesnake Adit
Rattlesnake Spring
Bunkhouse Springs
North Borrow Springs
BUTTRESS DUMP
LAD AREA
TAILING IMPOUNDMENT NUMBER 1
TAILING IMPOUNDMENT NUMBER 2
FUTURE WTP LOCATION
INTERSTATE 90
STATE HIGHWAY 2
PW-47
PW-11
PW-5
PW-19
PW-4
PW-22
MW200
MW201
MW-209
MW-210
MW-211
MW-212
MW-213
MW-214
MW-215
GW-18
GW-17
GW-49
GW-47
GW-48
ET-10
ET-11
GW-51
SH-1
LEGEND
Potentiometric Contour Line (50 Foot Interval)
0
750
1500
Scale in Feet

Figure 3-6 potent.dwg

GENERALIZED POTENTIOMETRIC MAP OF THE TERTIARY/QUATERNARY SEDIMENTS EAST OF THE PIT (May - June 2003)

FIGURE 3-6

3.3.3 Groundwater Quality

The 1997 Draft EIS, Chapter III, Section B.2.b described groundwater quality in the GSM project area as highly variable and identified eight regions with distinct water quality characteristics, some of which are related to mine facilities. For the purpose of the SEIS, updated water quality data obtained from GSM's annual reports (GSM, 1998-2003) for groundwater monitoring wells, springs, and the pit sump (see Figure 3-5 for well and spring locations) were reviewed for trends in acidity (measured in pH standard units) and sulfate concentrations that might indicate changes relevant to the alternatives analyzed. The majority of monitoring wells and springs exhibit stable ranges of pH and sulfate.

The following trends were observed in the data:

- A small number of wells in the bedrock aquifer and the Tdf/colluvial aquifer (PW-8, PW-11, PW-14, and PW-15) show decreases in sulfate concentrations that appear to correlate to decreasing water-level trends (Figure 3-5).
- PW-6, which is located south of the pit in the bedrock aquifer, reflects a decrease in pH from a range of 5-6 to 3 (Figure 3-5). The well also experienced a decreasing water-level trend during this period.
- PW-17, which is located down gradient from Stepan Spring in the bedrock aquifer, had a strong increase in sulfate concentration between 1997 and 2000. Reclamation work in the Stepan Spring area in late 1999 (see discussion in Section 3.3.4) has reversed the sulfate trend in PW-17 (Figure 3-5).
- The pit sump water quality has been monitored from 1999 to present. Water quality decreased substantially in early 2002, coincident with allowing pit water to collect in rubble at the bottom of the pit. The pH range of the pit water decreased from 5-7 to 4-5, and the sulfate concentration increased from approximately 5,000 milligrams/liter (mg/l) to 20,000 mg/l.

3.3.4 Seeps and Springs

Concerns were raised during the MAA process that seeps and springs at GSM may have been affected by mining operations. A detailed analysis of springs in the GSM project area was presented in Chapter III, Section III.2.B.d of the 1997 Draft EIS. A summary of the spring survey with updated water quality information as of December 2002 is presented in Table 3-1 with spring and well locations shown on Figure 3-5.

Most springs and seeps within the area generally discharge only a few gallons per minute, and some can cease flowing during dry seasons when the water table is low. The major springs and seeps that have been mapped within and adjacent to the pit area include Rattlesnake Spring, Bunkhouse Springs, Stepan Spring, and Stepan Original Spring.

Some springs downgradient of the pit area have ARD signatures (low pH, elevated concentrations of sulfate, and trace metals). These include Rattlesnake Spring, Bunkhouse Springs, Stepan Spring, Stepan Original Spring, and North Borrow Springs (Table 3-1). All of these, with the exceptions of Bunkhouse Springs and North Borrow Springs, can be associated with mineralized geologic structures or with abandoned mine adits which interconnect to mineralized zones (Gallagher, 2003a). The abundance of 11,000-year-old ferricrete associated with Rattlesnake Spring, Bunkhouse Springs, Stepan Spring, and Stepan Original Spring indicates that ARD discharge is likely to have occurred for thousands of years before mining began. Bunkhouse Springs occurs within Tertiary debris flow deposits and may originate due to the presence of discrete high permeability conduits within the colluvium.

A reclamation project was conducted at the site of Stepan Spring in late 1999 due to a trend of decreasing water quality thought to be related to dump face runoff from the South Dump (Gallagher, 2003d) (Figure 1-2). The reclamation project included:

- Completion of the reclamation of the South Dump and channeling of the historic flow from the toe area;
- Removal of pre-GSM historic mining waste rock and debris;
- Excavation of a channel;
- Placement of a substrate of pebble-sized limestone;
- Placement of a growth medium;
- Creation of benches between the channel and the sides of the gulch;
- Covering areas with limestone armoring; and,
- Placement of straw and seeding the entire area with dryland and wetland species.

The reclamation project has resulted in an overall improvement in water quality and a decrease in flow rate (personal communication (GSM data), Gallagher, June 30, 2003).

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Table 3 - 1 Summary of Springs Downgradient of the Pit

Spring/ Seep Name	Location[1] (shown on Figure 3-5)	Elevation[2] (feet)	Origination[1]	Flow Rate[3] (gpm)	WQ[4]		Other
					pH	Sulfate (ppm)	
Rattlesnake	Southeast of plant site along Rattlesnake Fault	4,940	believed to originate in adit; represents regional system discharge (constant rate)	baseflow 0.2 to 0.6	(3.8-5.3) slightly acidic	309 to 359	represents Bozeman Group aquifer water and upgradient bedrock aquifer (mineralized) water
Bunkhouse	Southwest of Rattlesnake Spring (RS), south end of RS Block	4,930	surface expression of the regional water table in the area	0.6 to 7 (baseflow 1-2)	(4.3-6.8) slightly acidic	598 to 733	receives flow from mineralized zones, reacts to precipitation events
Stepan	Southeast of the South Dump	5,025	represents discharge from mineralized zones in bedrock aquifer	0.2 to 1.4	(2.8-4.7) acidic	1,760 to 9,170	does not receive substantial recharge from drainage area
Stepan Original	1,600 feet southwest of Stepan Spring	4,888	collapsed abandoned adit; represents regional groundwater which has traveled through mineralized zones in bedrock aquifer	0.8 to 2.8	(5.2-6.2) slightly acidic to neutral	1,790 to 2,200	Measurement range attributed to inconsistent measurement methods; little variation in flow

Buried springs/seeps (engineered systems)

North Borrow	120 yards north of Tailings Impoundment No. 1 in Rattlesnake Gulch drainage	4,790	created when North Borrow area excavated below shallow water table	8 to 32	(3.9-6.3) slightly acidic	not reported	intercepted by an underdrain; area filled by Buttress Dump expansion

[1] summarized from 1997 Draft EIS text, Chapter III, Section B.2.d

[2] estimated from "Generalized Potentiometric Map of Late Season 1993 Groundwater Conditions in GSM Project Area"; elevations relative to GSM datum; minus 91.4 feet to convert to USGS datum

[3] summarized from GSM Pit Area Spring and Seep Data 1990 to 2002 (Gallagher, 2003b; GSM 2003 annual report)

[4] read off graphs in 1997 Draft EIS text, Chapter III, Section B.2.d

3.3.5 Groundwater in the East Waste Rock Dump Complex

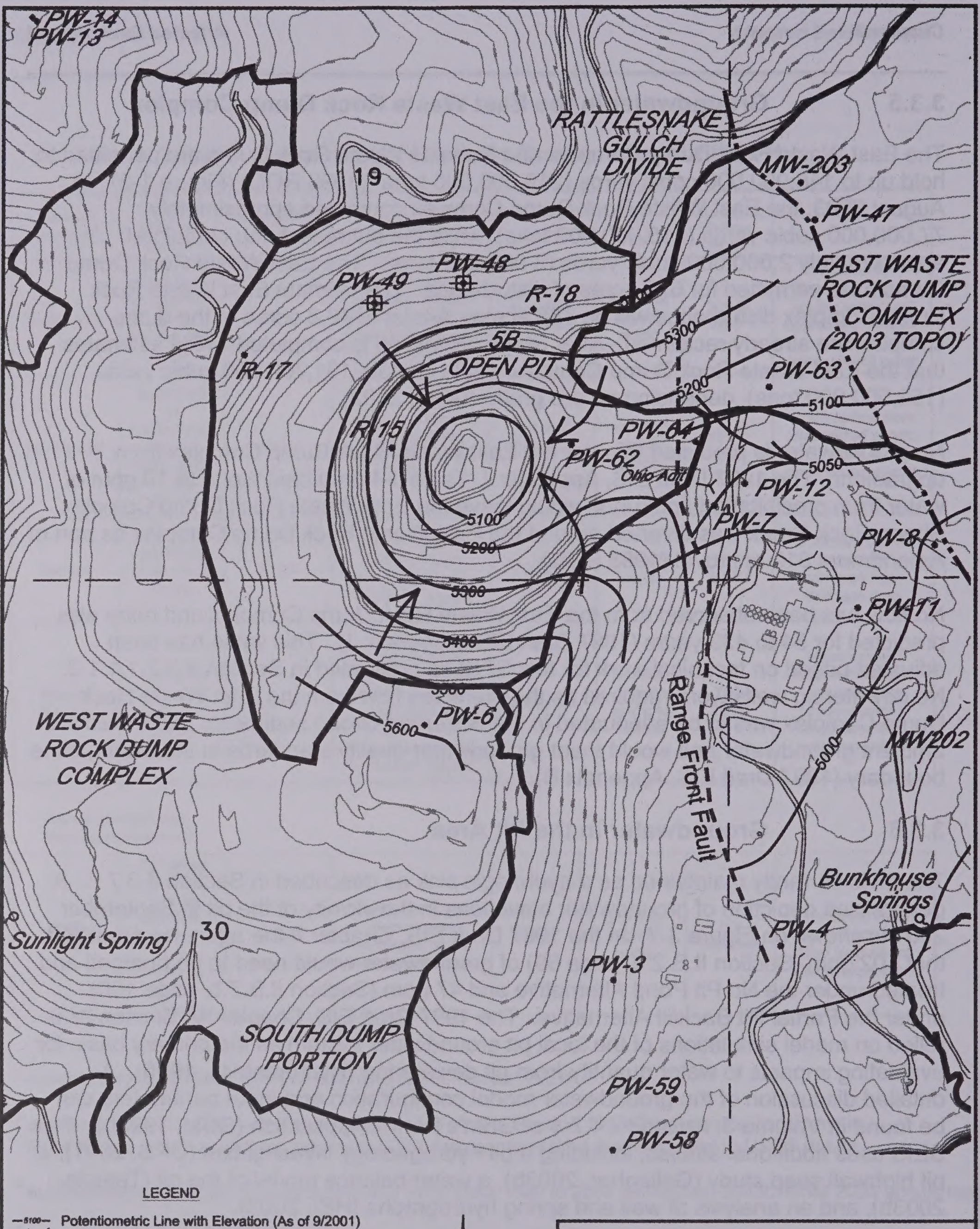
The East Waste Rock Dump Complex and Buttress Waste Rock Dump are permitted to hold up to 146,000,000 cubic yards (219,000,000 tons) (1998 ROD) (Figure 1-2). In August 2003, the East Waste Rock Dump Complex contained approximately 77,000,000 cubic yards (115,000,000 tons), while the buttress dump contained approximately 2,000,000 cubic yards (3,000,000 tons). The East Waste Rock Dump Complex is permitted for 670 acres of disturbance. The ultimate East Waste Rock Dump Complex disturbance will be 438 acres. A total of 76.8 acres of the dump complex are already reclaimed. After Stage 5B mining is completed, GSM estimates that the East Waste Rock Dump Complex would contain 101,700,000 cubic yards (152,500,000 tons), depending on ore grade (GSM, 2002).

No groundwater is predicted to enter the East Waste Rock Dump Complex from upgradient. The 1997 Draft EIS, Appendix J, Table J-4 predicted that 6 to 10 gpm of water from precipitation and runon would leave the East Waste Rock Dump Complex. Sheep Rock Creek was diverted around the East Waste Rock Dump Complex as part of Amendment 010 approval (1998 ROD).

No flow has been observed from the East Waste Rock Dump Complex and none was predicted for 54 to 433 years (1997 Draft EIS, Appendix J). This value has been adjusted based on technical work for this SEIS as presented in Section 4.3.2.1.1.1.2. No dewatering wells were required as the predicted flow from the East Waste Rock Dump Complex was to be attenuated in the Bozeman Group sediments and mixed with ambient groundwater and would meet groundwater quality standards at the mixing zone boundary (1997 Draft EIS, Appendix B).

3.3.6 Groundwater in the Pit Area

The pit is currently maintained as a hydrologic sink as described in Section 3.3.7.2. A generalized depiction of groundwater elevations in the vicinity of the pit in September 2001 is shown on Figure 3-7. In the 1997 Draft EIS, Chapter II the agencies predicted that 102 gpm (Section II.B.2.b, page 69) of groundwater would need to be pumped and treated under the No Pit Pond Alternative and 47 gpm (Section II.B.7.b, page 100) under the Partial Pit Backfill Alternative. The 1997 Draft EIS, Chapter IV, Section IV.B relied on model simulations of the local pit groundwater system as the primary basis for evaluating impacts to water quantity from pit dewatering (Hydrometrics, 1995). A detailed discussion of the groundwater model configuration and input parameters can be found in Volume 3, Appendix 4.7-1 of GSM's Permit Application (GSM, 1995b). This SEIS uses additional studies, including a pit hydrogeology investigation (URS, 2001), a pit highwall seep study (Gallagher, 2003b), a water balance model of the pit (Telesto, 2003b), and an analysis of well and spring hydrographs (HSI, 2003).


PW-14
PW-13
RATTLESNAKE GULCH DIVIDE
19
MW-203
PW-47
EAST WASTE ROCK DUMP COMPLEX (2003 TOPO)
PW-48
PW-49
R-18
5400
5300
5B OPEN PIT
R-17
PW-63
5200
5100
R-15
PW-64
PW-62
Ohio Adit
5050
PW-12
5100
PW-7
PW-8
5200
5300
PW-11
5400
Range Front Fault
5500
WEST WASTE ROCK DUMP COMPLEX
5600
PW-6
MW202
5000
Bunkhouse Springs
Sunlight Spring
30
PW-4
PW-3
SOUTH DUMP PORTION
PW-59
PW-58
LEGEND
5100 Potentiometric Line with Elevation (As of 9/2001)
Groundwater Flow Direction
PW-6 Groundwater Monitoring Well
Approximate Location of Range Front Fault
PW-49 Existing Dewatering Wells
Source: GSM Operating Permit No. 00065
Partial Pit Backfill Plan - October, 2002
0
500
1000
Scale in Feet
Figure 3-7 gwflow.dwg

GENERALIZED POTENTIOMETRIC SURFACE OF GSM OPEN PIT AREA

FIGURE 3-7

Faults and fractures control the permeability of the bedrock aquifer in the pit area and act as the conduits of groundwater flow into the pit. During mining, the pit has been continually dewatered from within the pit and from two dewatering wells on the north side of the pit (PW-48 and PW-49 as shown on Figure 3-5). From 1995 through 2001, 43 pit highwall seeps were cataloged by GSM, some of which are probably duplicative, due to the changing pit configuration and seep locations over time (Gallagher, 2003b). The most seepage was found as the pit penetrated the Corridor Fault. In general, while new seeps have been identified as the pit was enlarged and deepened, total flow from seeps has not changed proportionately. At present, most groundwater flows into the pit along the north wall of the pit where the Corridor Fault is intersected. On the south pit highwall, the Sunlight and Fenner faults appear to be secondary sources of groundwater inflow (Figure 3-2).

The 1997 Draft EIS and other previous reports used the term "regional groundwater flow" to describe the majority of groundwater that flows into the pit. Fetter (1980) describes a regional flow system as having its recharge area at the basin divide and discharge area at the valley bottom. Local and intermediate flow systems have shorter flow paths that are influenced by variations in local topography, and may react quickly to precipitation events. Additional analyses indicate that most of the groundwater inflow to the pit is best characterized as intermediate and local groundwater flow (Gallagher, 2003a). Recharge to the pit is generally topographically controlled and is conveyed primarily by structures having higher permeability. Precipitation events were found to be responsible for the largest variations in pit highwall seep flows (Gallagher, 2003b). Precipitation events result in an almost immediate increase in flow (local flow system) from major seeps along the Corridor Fault. A general decay of the flow rate can be observed over time following a precipitation event, indicating influence from the intermediate flow system.

Gallagher's (2003b) spring and seep report also described the geologic structural controls, lithologic controls, and engineering/blasting controls on pit highwall seepage. A disturbed rock zone caused by conventional blasting and mining extends several feet to tens of feet into the pit highwall. This zone tends to funnel pit highwall inflows downward, where the seepage may reach the pit bottom, or may emerge as pit highwall seeps. As described in Section 3.2.2.3, GSM has refined its blasting method in the lower portion of the pit, which has reduced the thickness of the disturbed rock zone.

Based on GSM's experience in dewatering the pit for the past 5 years and a new pit water balance model (Telesto, 2003b), the total net inflow to the pit (total inflow minus evaporation) is projected to be 32 gpm for the No Pit Pond Alternative. The 1997 Draft EIS, Chapter IV, Section IV.B.2.b projected a maximum total net inflow of 102 gpm for the No Pit Pond Alternative. The difference between the two estimates is due to an earlier underestimation of evaporation, less than predicted pit inflows, and the potential influence of drought. The hydrogeologic and water balance studies performed for the SEIS predict that for a 10-year time-weighted average, 94 percent (119 gpm) of the inflow to the pit would be direct precipitation and runon, with about 6 percent (8 gpm) entering as groundwater inflow through seepage along faults and fractures, primarily from the Corridor Fault (Telesto, 2003a). Faults penetrating the lower portions of the pit yield much less water than the Corridor Fault. The underground mine, which reaches approximately 300 feet (4,400-foot elevation) beneath the current pit bottom, had very small amounts of inflow after fractures drained, and water was imported to maintain underground mining operations.

The new water balance study predicts that for the Stage 5B pit, nearly three-quarters (98 gpm) of the water that enters the pit will exit as evaporation. The highwall has a high evaporation potential due to its aspect, color, and large surface area. Most water enters the pit at or above the bottom of the Corridor Fault, and must flow over a large portion of exposed rock in order to reach the bottom of the pit, thus resulting in a large evaporation loss. Some water may also be lost during exothermic reactions with exposed sulfides.

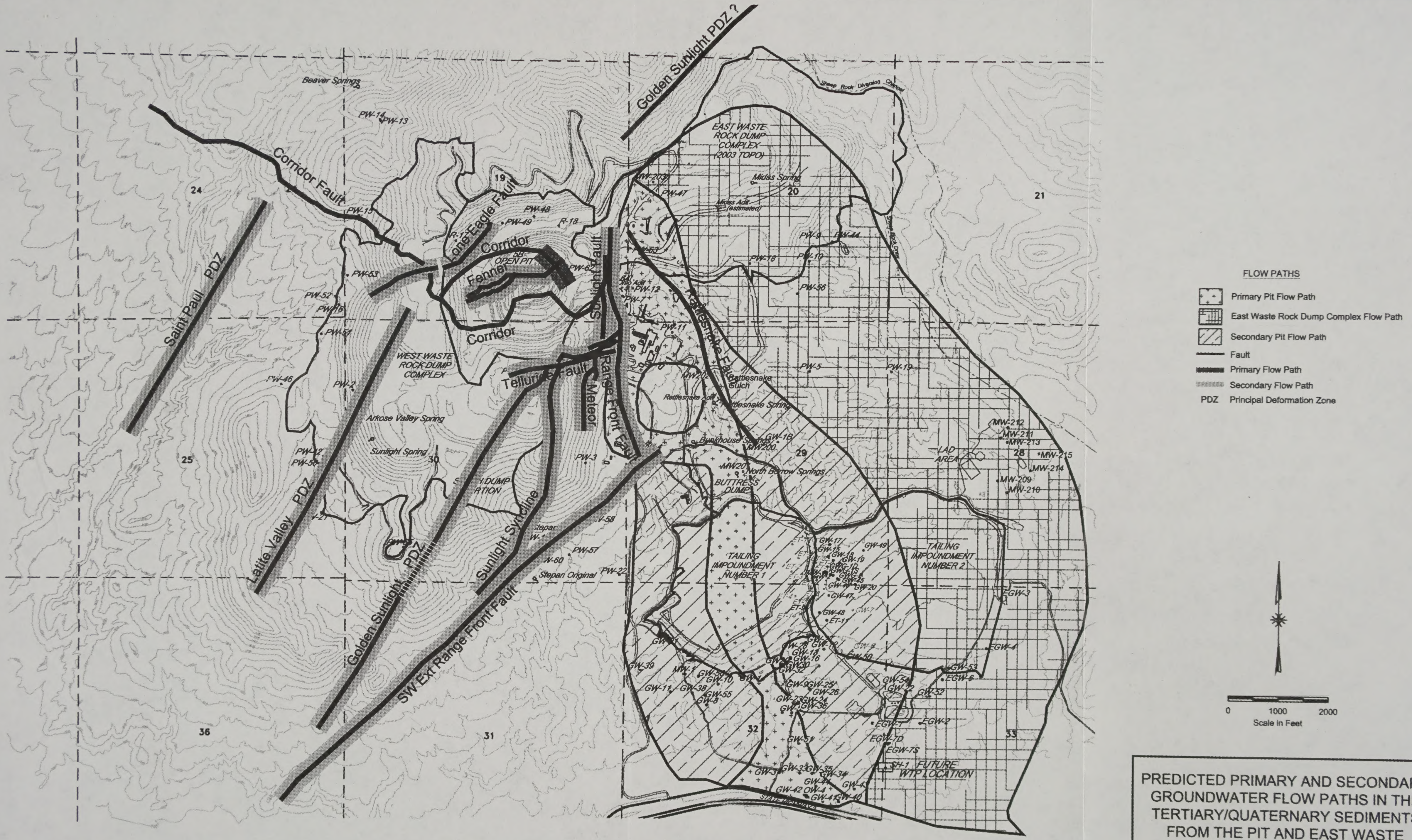
3.3.7 Groundwater Flow Paths

3.3.7.1 Groundwater Flow Path from the East Waste Rock Dump Complex

Groundwater flow beneath the East Waste Rock Dump Complex is to the south, principally in the Tertiary gravels and Tertiary alluvial deposits initially, transitioning into the Tertiary fluvial deposits farther south. Although the bulk permeability of the Bozeman Group aquifer is not high, beds of fine to coarse sandstone and pebbly conglomerate do provide preferential pathways for groundwater movement. Groundwater beneath the 13 percent portion of the East Waste Rock Dump Complex in the Rattlesnake Gulch drainage would likely report to the Tertiary to Quaternary debris flow and alluvial channel deposits in Rattlesnake Gulch.

Below the veneer of Quaternary deposits, typically 80 feet (ranges from 60 to 150 feet) of unsaturated Tertiary sediments underlie the East Waste Rock Dump Complex (HSI, 2003). Saturation is present in the lower portion of the Tertiary gravels and Tertiary alluvial deposits. The earth slip blocks that moved at GSM in 1994 moved on or near the contact of the Tertiary alluvial and Tertiary fluvial deposits (Golder, 1995a). About seventy percent of the East Waste Rock Dump Complex overlies Tertiary deposits. The groundwater flowpath down gradient of the East Waste Rock Dump Complex is principally in Tertiary alluvial and Tertiary fluvial deposits. The potentiometric map of the T/Q alluvial aquifer (Figure 3-6) indicates that this groundwater flow system is hydrologically connected to the Jefferson River alluvial aquifer, approximately 12,500 feet to the south.

The 1997 Draft EIS, Appendix J, Table J-4 predicted that 6 to 10 gpm of water would leave the dump and follow the groundwater flow path from the East Waste Rock Dump Complex to the Jefferson River alluvial aquifer (Figure 3-8). This flow path is interpreted to be hydraulically controlled, that is, dictated by the potentiometric gradient.


Golden Sunlight PDZ ?
Beaver Springs
PW-14
PW-13
Corridor Fault
Sheep Rock Diversion Channel
EAST WASTE ROCK DUMP COMPLEX (2003 TOPO)
Midas Spring
Midas Adit (estimated)
24
19
20
21
25
30
29
28
36
31
32
33
PW-15
PW-48
PW-49
R-18
R-17
Lone Eagle Fault
Corridor
Fenner
OPEN PIT
Sunlight Fault
PW-53
PW-52
PW-16
PW-51
Saint Paul PDZ
Corridor
WEST WASTE ROCK DUMP COMPLEX
Telluride Fault
Range Front Fault
Meteor
Rattlesnake Fault
Rattlesnake Gulch
Rattlesnake Adit
Rattlesnake Spring
Bunkhouse Springs
North Borrow Springs
BUTTRESS DUMP
PW-46
PW-2
Arkose Valley Spring
Sunlight Spring
PW-12
PW-50
PW-3
PW-9
PW-44
PW-18
PW-10
PW-56
PW-12
PW-7
PW-11
PW-5
PW-19
PW-47
MW-203
MW-202
MW-200
MW-201
GW-18
Latite Valley PDZ
Golden Sunlight PDZ
Sunlight Syncline
SW Ext Range Front Fault
PW-57
PW-58
PW-22
PW-27
N-60
Stepan Original
TAILING IMPOUNDMENT NUMBER 1
TAILING IMPOUNDMENT NUMBER 2
LAD AREA
MW-212
MW-211
MW-213
MW-215
MW-214
MW-209
MW-210
EGW-3
EGW-4
EGW-5
EGW-2
EGW-1
EGW-7D
EGW-7S
GW-53
GW-52
GW-54
GW-39
GW-11
GW-38
GW-55
GW-51
GW-35
GW-34
GW-42
GW-41
GW-40
FUTURE WTP LOCATION
STATE HIGHWAY 2
FLOW PATHS
Primary Pit Flow Path
East Waste Rock Dump Complex Flow Path
Secondary Pit Flow Path
Fault
Primary Flow Path
Secondary Flow Path
PDZ Principal Deformation Zone
0
1000
2000
Scale in Feet

PREDICTED PRIMARY AND SECONDARY GROUNDWATER FLOW PATHS IN THE TERTIARY/QUATERNARY SEDIMENTS FROM THE PIT AND EAST WASTE ROCK DUMP COMPLEX

FIGURE 3-8

Figure 3-8.dwg

About 13 percent of the East Waste Rock Dump Complex at the southwestern tip overlies debris flow deposits that are part of the same sand and gravel flowpath described below for the pit. Groundwater beneath this area migrates south, mixes with other groundwater in the Tdf/colluvial aquifer, and continues to move down gradient in that flow path along Rattlesnake Gulch. The 1997 Draft EIS, Chapter IV, Section IV.B.1.e predicted that 200 gpm of natural groundwater would flow down Rattlesnake Gulch and would have to be collected and treated with Tailings Impoundment No. 1 seepage. GSM drilled the Rattlesnake Gulch dewatering wells above Tailings Impoundment No. 1 in 1994 in association with the Buttress Dump (Figure 3-5). Most of this water is now captured by the wells and does not mix with tailings impoundment seepage. The rest of the groundwater flow is subject to capture by the south pumpback system that collects seepage from Tailings Impoundment No. 1 (Figure 3-5). Any uncaptured groundwater may reach the Jefferson River alluvial aquifer via coarser units within the Bozeman Group aquifer.

3.3.7.2 Groundwater Flow Paths from the Pit Area

The open pit is currently maintained as a hydrologic sink by pumping from the bottom of the pit and two highwall dewatering wells (PW-48 and PW-49, Figure 3-5). Under current conditions, all of the water entering the pit area is believed to be captured by the pit, and removed by evaporation or pit dewatering activities.

The primary historic flow path out of the pit area was the Corridor Fault, which was encountered at an elevation of approximately 5,250 feet near the northeast corner of the pit (URS, 2001; Gallagher, 2003b; Telesto, 2003b). In addition, other, less permeable structural flow paths exist lower in the pit. The hydrogeologic setting, along with the previous documentation of abundant ferricrete deposits in the T/Q materials immediately below the east and southeast side of the pit, as discussed in Section 3.3.6, provide evidence that the principal groundwater pathway from the pit area would have been via the Corridor Fault east and southeast to subsurface discharge beneath the access road area to the Rattlesnake Gulch drainage.

Some of this flow would be intersected by the Range Front Fault and migrate south to the intersection with the southwest extension of the Range Front Fault where some flow would likely travel along that fault and some flow would likely enter the sediments above Tailings Impoundment No. 1.

As mentioned in Section 3.3.7.1, the 1997 Draft EIS, Chapter IV, Section IV.B.1.e estimated that 200 gpm would flow beneath Tailings Impoundment No. 1, the majority of which would be groundwater flow from the Rattlesnake Gulch drainage area. The 1997 Draft EIS stated that 200 gpm was a conservatively high estimate and predicted that the flow would diminish based on operation of the various pumpback systems near Tailings Impoundment No. 1 and the Rattlesnake Gulch interception wells. Based on data collected by GSM since 1998, the pumping rate from the Rattlesnake Gulch interception wells is currently approximately 50 gpm and continues to decrease over time (GSM 2003 annual report).

A continuous high permeability pathway of Tertiary debris flow deposits from the pit to the north end of Tailings Impoundment No. 1 was mapped (Golder, 1995a). These debris flow deposits would be the potential primary flow path from the pit area if the pit were to become fully saturated (i.e. if a pit lake were to form, or if the pit were backfilled and water saturated). The Tertiary debris flow deposits appear to convey the majority of groundwater flow in the Rattlesnake Block (Figures 3-3 and 3-8). The relatively high permeability of these deposits is supported by the 52 gpm average yield of the Rattlesnake interception wells, and the far-reaching drawdown documented on the basis of hydrograph analysis (HSI, 2003).

The Tertiary debris flow gravel channel continues beneath the northern portion of Tailings Impoundment No. 1 and is hydrologically connected to the Jefferson River alluvial aquifer via younger alluvial channel deposits (HSI, 2003). This conclusion is supported by examination of numerous well logs and the contaminant migration patterns below the impoundment. Previous hydrogeologic studies by Hydrometrics (1994 and 1997) used in the 1997 Draft EIS and by Keats (2001 and 2002) have identified this sand and gravel channel. Plotting of drilling logs from all studies demonstrates the continuity of this gravel channel from the pit to the river.

Secondary potential groundwater flow paths in the Tertiary/Quaternary deposits from the pit have been designated on Figure 3-8, based on the potentiometric head patterns. While the Tertiary debris flow channel in Rattlesnake Gulch is clearly the preferential pathway, potentiometric contours indicate that groundwater flow into the Bozeman Group aquifer on either side of the channel is consistent and should be considered as a secondary flow path. The Tertiary fluvial materials have been characterized as having higher clay content, generally lower permeability, and discontinuous sandstone beds (Golder, 1995a). However, GSM's experience in capturing groundwater below Tailings Impoundment No. 1 demonstrates that once tailings impoundment seepage is introduced to the Tertiary fluvial sandstone aquifer, it moves readily and less predictably than in the alluvial channel sand and gravel deposits (Keats, 2001 and 2002).

Secondary groundwater flow paths from the pit are the principal faults and geologic structures in the bedrock aquifer, other than the Corridor Fault, which is considered a primary flow path. These structures and faults could provide conduits for groundwater transport (Figure 3-2). The principal features of concern are:

- The Range Front Fault east of the pit;
- The east-west trending Telluride Zone and connected Sunlight Fault to the north and Meteor Fault south of the pit;
- The Golden Sunlight Principal Deformation Zone (PDZ) south of the pit;
- The Sunlight Syncline south of the pit (likely the source of Stepan Spring);
- The Latite Valley PDZ southwest of the pit;
- The Fenner Fault, which contributes water to the pit at present but is not mapped outside of the pit;
- The Lone Eagle Fault and potentially connected unnamed faults extending west of the pit; and,

- The Saint Paul PDZ may be connected via mapped faults west of the pit.

As described in Section 3.2.1.5, the extensive ferricrete deposits and gold enrichment along and downgradient of the Range Front Fault suggest that groundwater transport of metalliferous fluids from the area of the pit has occurred in the past. The ferricrete appears to be evidence that discharge along the fault found its way into the Tertiary materials, where it joined the flow paths discussed above.

All the springs on the mine site associated with adits are on or associated with some type of geologic structure or mineralized area (Gallagher, 2003e). Springs are shown on Figure 3-5. Rattlesnake Spring lies on the northwest-trending Rattlesnake Fault. Its water chemistry contains ARD effects indicative of a hydrologic connection to mineralized zones in Bull Mountain. The Arkose Valley Spring is associated with the Latite Valley PDZ. Many small faults and structures surround Bunkhouse Springs and North Borrow Springs, but these springs do not appear to be related to the faults. South of Bull Mountain, Stepan Spring lies directly over the Sunlight Syncline, suggesting a connection to this geologic structure. The Sunlight Syncline is mapped as a continuous feature from the pit area to Stepan Spring (GSM, 1996). The shape and structure of the syncline funnel ARD from mineralized zones in and south of the pit to Stepan Spring. The thick ferricrete deposits at the spring indicate that ARD transport and deposition have been a long-term occurrence at this location.

Some of the highest yielding wells at GSM lie on faults. PW-60, for example, produces an estimated 40 gpm and lies directly on the unnamed southwest extension of the Range Front Fault (Figure 3-2). PW-21, reported to yield up to 60 gpm, lies on the Latite Valley PDZ. Conversely, no high-yielding wells in the Proterozoic aquifer have been found away from mapped faults. Considering the limited number of monitoring wells installed along faults, and uncertainty of intersecting faults at depth, this apparent association of preferential permeability along faults and other types of geologic structures, although based on limited data, was considered important. Thus, mapped faults which may be traced to the pit area were considered as one of several factors in evaluating hydrologic connection to the pit.

A study of well and spring hydrographs indicated that the below average precipitation of the past 4 to 5 years has likely influenced groundwater levels in all aquifers monitored (HSI, 2003). This obscures any potential of observing indirect evidence of a hydrologic connection from fault-oriented springs and wells to the pit.

3.4 SOILS AND RECLAMATION

The 1997 Draft EIS, Section III.C described the soils within the permit area. Generally, the soils around the pit are on steep slopes and are rocky, shallow, and poorly developed. Soils are salvaged and stockpiled for reclamation purposes. There is a shortfall of stockpiled topsoil for the partial pit backfill alternatives. Additional soils, if needed, would be salvaged from the area permitted for the East Waste Rock Dump Complex and a borrow area north of Tailings Impoundment No. 2 (GSM, 2002). These soils are generally on less steep slopes and are less rocky, deeper, and more developed than the soils around the pit. Table 3-2 presents information on the suitability of soils that could be disturbed under the alternatives.

Table 3 - 2 Soil Suitability as Cover

GSM Site Area	Soil Suitability
Western Portion	Soil coarse fragment contents (gravel-, cobble-, and rock-sized geologic materials) are typically somewhat higher in the western portions of the project area. Coarse fragment content has a dual effect on the quality of soils for revegetation purposes. The higher the volume of coarse fragments (assuming the fragments do not readily weather to soil) the less the available water holding capacity of the soil for any given soil texture. For example, a loam soil containing no coarse fragments can store approximately 2.0 inches of water per foot of soil material. A loam soil containing 20 percent coarse fragments can store approximately 1.6 inches of water, while a loam soil containing 50 percent coarse fragments is capable of storing 1.1 inches of water. Conversely, coarse fragments occurring on the soil surface decrease the susceptibility of soil to erosion by providing an "armoring effect". The calcium carbonate content and pH buffering capacity of the dominant soils of this area are low.
Eastern Portion	With respect to overall soil characteristics and soil salvage potentials, the soils of this portion of the project area typically overlie less steep slopes, are deeper, have lower coarse fragment contents, and have higher pH values than the soils of the western portion of the project area. These soils have, in part, developed on limestone as well as calcareous loess and have a net buffering capacity due to the calcium carbonate content.

3.5 WILDLIFE

Wildlife resources are addressed in the 1997 Draft EIS, Section III.E. A summary of that information is presented below.

A variety of habitats utilized by resident and migratory wildlife species are found within the general vicinity of the GSM pit. The mule deer is the most common big game species in and around the existing mine site. Several bat species use abandoned mines for roost sites, including winter hibernacula. Bat surveys identified several *Myotis spp.* and big brown bats flying in the vicinity of the mine (GSM, 1995b). A fringed myotis was captured during the surveys and released. Five hibernating big brown bats were observed in one of the four abandoned mines surveyed.

3.6 CULTURAL RESOURCES

Cultural resources are addressed in the 1997 Draft EIS, Section III.L.

Cultural resources consist of prehistoric and historic archaeological deposits; structures of historic or architectural importance; and traditional ceremonial, ethnographic, and burial sites. Cultural resources are nonrenewable resources, which are afforded protection by federal, state, and local laws, ordinances, and guidelines.

Several previous archaeological surveys have been conducted in the vicinity (Peterson and Mehls 1994). Reports detailing the results of intensive archaeological evaluations conducted in the GSM area are on file at the BLM Butte Field Office and at the SHPO office in Helena. The only cultural resource that might be affected by pit reclamation is a historic cabin near the north highwall. Should an alternative involving cast blasting be selected, there would be an adverse impact to this historic property, which would require mitigation.

3.7 SOCIOECONOMIC CONDITIONS

Area economy, employment, taxes and income were described in detail in the 1997 Draft EIS, Chapter III, Section III.J, pages 204 through 213. This section updates the data from 1997 to present.

3.7.1 Employment

In 1998, GSM employed 202 full-time personnel, 11 part-time personnel and 39 contractors. As of March, 2004, GSM employed 132 full-time personnel and 17 contractors.

Jefferson County is a rural county, with culture and economy historically dependent upon the land. Early economic activities were related to the extraction and utilization of natural resources. The mineral wealth found in the mountains and valleys of western Montana stimulated the county's initial growth. Other activities such as timbering, grazing, and agriculture followed. Natural resource and service industry activities dominate the economy and culture (U.S. Census Bureau, 2000, www.census.com).

The mining sector provides significant contributions to employment in Jefferson County. GSM provided 160 jobs in 2003 accounting for approximately 4.3 percent of total covered employment. Secondary employment, primarily in the services sector, also is supported in the community by mining jobs at GSM. Table 3-3 shows employment information for Jefferson County and the State of Montana since the 1997 Draft EIS.

Table 3 - 3 Jefferson County and State of Montana Employment and Income

	Jefferson County		Montana	
Population (2001)	10,405		904,433	
Labor Force (2000)	5,183		458,306	
Unemployment Rate (2001)	3.5%		4.1%	
Per Capita Income (1991)	$18,250		$17,151	
Median Household Income (1999)	$41,506		$33,024	
Employment Sector (2000)	**Number Employed**	**Percent of Employment**	**Number Employed**	**Percent of Employment**
Ag/Forestry/Fishing & Hunting/Mining	410	8.4	33,691	7.9
Construction	411	8.4	31,724	7.4
Manufacturing	186	3.8	25,414	6.0
Transportation and Warehousing and Utilities	236	4.8	23,109	5.4
Wholesale Trade	120	2.5	12,937	3.0
Retail Trade	424	8.7	54,468	12.8
Finance/Ins/Real Estate	320	6.5	23,351	5.5
Services	2,034	41.6	195,988	46.1
Public Administration	754	15.4	25,295	5.9
Total, All Industries	**3,680**	**100**	**425,977**	**100**

Note: Source U.S. Census Bureau, 2000, www.census.gov
Note: Services Industry includes professional, scientific, management, administrative and waste management services; educational, health and social services; arts, entertainment, recreation, accommodation and food services; "other services" (except public administration); and information.

3.7.2 Tax Revenues

Table 3-4 provides the specific GSM economic contribution to the State of Montana. Since it began production in 1982, GSM has paid taxes to the state, county, and local communities in the form of the metals mine license tax, the gross proceeds tax, and other taxes. GSM's taxing district includes Whitehall High School and Cardwell Elementary.

Table 3 - 4 Economic Contributions of GSM

	1985	1990	1995	2000 (1)	2002	Total Since 1983
Gold Ounces Produced	**96,491**	**97,058**	**89,799**	**212,266**	**111,806**	**2,302,549**
Number of Employees	**146**	**259**	**301**	**92**	**83**	**193 (avg)**
Total Gross Payroll, Payroll Taxes, and Employee Benefits Paid	**$5,872,556**	**$11,934,434**	**$15,157,626**	**$7,679,237**	**$6,296,899**	**$205,977,606**
Total Property Taxes, Gross Proceeds Tax, and Metal Mines License Tax Paid	**$838,632**	**$1,645,634**	**$1,229,379**	**$1,873,003**	**$1,623,460**	**$28,441,051**
Total Purchases	**n/a**	**n/a**	**$35,007,164**	**$21,232,000**	**$27,354,151**	**$337,226,454***
Total Employee Taxes	**$355,098**	**$722,281**	**$3,028,753**	**$1,649,999**	**$1,048,225**	**$32,416,552**

(1) In addition, 65 employee reduction in force $1,306,132 plus $102,741 in benefits
* - Since 1991 only
Source – GSM, personal communication, 2003

The latest Jefferson County and State of Montana revenue figures for fiscal year 1998 and 2002 are shown in Table 3-5. County tax revenues are confined primarily to the property tax, which is assessed based on the total taxable value for the county and the consolidated mill levy (Jefferson County, January 6, 2004).

Table 3 - 5 Jefferson County and State of Montana Revenues

Revenue Category	**1998**		**2002**		**2002 Percent GSM of Total**
	GSM	Total County	GSM	Total County	
Property Tax	$551,062	$8,468,801	$309,232	$8,131,529	3.8%
Gross Proceeds Tax	$389,771		$492,362		
Metal Mines License Tax	$847,243		$821,866		

3.8 LAND USE AND ACCESS

Land Use and Access is addressed in the 1997 Draft EIS, Section III.H. A summary of that information is presented below. Today, the primary land uses in the pit area are wildlife habitat and mineral extraction.

The majority of surface land in the current GSM permit area is owned by GSM. The remaining surface lands consist primarily of BLM-administered tracts, with DNRC-administered school trust land in Sections 16 (T2N, R3W) and 36 (T2N, R4W).

The county's current mining operations provide employment and economic benefits for Jefferson County. The county recognizes that mining is a finite activity and it acknowledges the importance of expanding and diversifying the economic base. The Jefferson County Comprehensive Plan also emphasizes the value of "quality of life" issues and preserving environmental and cultural resources (Jefferson County, 1993).

The Jefferson County Comprehensive Plan Map depicts the area around the mine as "Basic Resource with Development Constraints," meaning that the land is to be protected for agriculture, timber, and mineral resource utilization. Lands with this designation may have development and use constraints including any of the following: public ownership, steep slope, flood susceptibility, poor access, lack of potable water supply, and/or fire suppression capability (Jefferson County, 1993).

GSM applied for a minor revision in December 2003 to leave the mill complex for post mine industrial use by Jefferson County. This change in land use was approved in 2004.

3.9 AESTHETIC RESOURCES

Aesthetic resources are addressed in the 1997 Draft EIS, Chapter III, Section III.I.

The BLM Visual Resource Management (VRM) system is designed to help manage the quality of the landscape by minimizing impacts to visual resources resulting from development activities, while maintaining the effectiveness of all BLM resource programs. Through the visual analysis process outlined in BLM Handbook 8410-1, Visual Resource Inventory, rating categories are assigned. The categories describe the relative value by analyzing three components - scenic quality, viewer sensitivity, and distance zone - to provide an assessment of the current visual resources. VRM Classes I to IV are then assigned for the area, with management objectives ranging from maintaining minimal visual disturbance to allowing activities that entail major landscape modifications. The BLM, to date, has not assigned a VRM Classification for the lands around GSM, although the area has generally been managed as a potential VRM Class IV area because of the existing mining disturbances.

A Visual Resource Inventory (VRI) was conducted for the 1997 Draft EIS and is discussed there in Chapter III, Section III.1. The results of the VRI yielded a Class III rating. The study area was defined as the ridgeline encompassing present mining activity and surrounding BLM lands and parts of the surrounding valleys. A Class III rating provides for moderate changes to the existing landscape and activities that may attract the attention but not dominate the view of the casual observer. Under a Class III rating, areas that currently do not conform to the management objectives would be designated as "Rehabilitation Areas"; these areas would be rehabilitated upon project completion to restore the natural characteristics of the landscape to the extent required for a Class III visual resource rating.

GSM has reclaimed 7 acres in the pit to date. GSM has planted tree seedlings along the upper pit highwall on the west and south sides of the pit. GSM has placed soil on the upper northwest corner of the pit to determine if revegetation can be successful with a small amount of soil placement.

3.10 SAFETY

Safety is an important issue at GSM. All work practices are conducted following GSM's Safety Manual (GSM, 1993; GSM, 2002a). The manual includes general safety rules as well as specific rules for each department. The general rules are considered to be the minimum standard. Safety and health education is a key component to GSM's safety program.

Placer Dome's goal is to eliminate workplace accidents. In 2001, Placer Dome embarked on a campaign to identify, profile and target the areas that would benefit most from more disciplined safety practices. They called this program the Critical Incident Initiative.

The purpose of the Critical Incident Initiative was to address four objectives:

- Identify the root cause of critical incidents;
- Benchmark the adequacy of GSM's management systems;
- Recommend necessary changes to achieve GSM's expectations; and,
- Assist GSM to implement the changes.

The Critical Incident Initiative is an ongoing, multi-year process.

In safety reporting, medical aid injuries are defined as occupational work-related injuries that require attention by a medical professional but do not result in lost time. Lost time injuries are defined as work-related incidents that cause a worker to require time off from work, including the current shift and at least one additional scheduled shift. All statistics are reported against these definitions.

On September 12, 2002, Placer Dome's new Health and Safety Charter went into effect. The Charter outlines Placer Dome's safety and corporate policies.

As of June 1, 2004, GSM employees and contractors had worked 181,745 hours without a lost time accident (LTA). GSM's non-fatal days lost rate currently is 0 compared to a MSHA national average of 2.89.

Chapter 4

Environmental Consequences

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Chapter 4

Environmental Consequences

4.1 INTRODUCTION

The 1997 Draft and 1998 Final EIS discussed impacts associated with pit reclamation alternatives. The information presented in this SEIS supplements these documents.

This SEIS addresses potential environmental consequences as a result of the Proposed Action, No-Action and other alternatives presented in Chapter 2. The most important issue in this SEIS, as determined through scoping including the MAA process, is the potential impact to groundwater. The open pit is the principal facility affected by the actions and alternatives of this SEIS. The East Waste Rock Dump Complex is partially affected since, for alternatives where backfill occurs, waste rock to backfill the pit would be obtained by removing about 33 percent of the volume from the top of the East Waste Rock Dump Complex as shown in Figure 2-6. The footprint of the East Waste Rock Dump Complex would not change.

In addition, 13 percent of the footprint of the East Waste Rock Dump Complex is in the Rattlesnake Gulch drainage. This means that part of the seepage from the dump complex would infiltrate below the dump and mix with ambient groundwater in Rattlesnake Gulch. This groundwater moves down the drainage toward the Jefferson River alluvial aquifer. Most of the seepage from the pit would also move down the Rattlesnake Gulch drainage, if the seepage cannot be contained within the pit. Hence, the following analysis discusses the alternatives and issues of concern with respect to the pit and the East Waste Rock Dump Complex and associated potential impacts to the environment.

This chapter describes the direct, indirect, and cumulative environmental consequences (both adverse and beneficial) for each of the pit reclamation alternatives. Many impacts are the same regardless of the alternative; however, other impacts are directly dependent on the reclamation measures in a specific alternative.

The impacts are described based upon the change that would occur to the existing resource conditions described in Chapter 3 if the alternative was implemented. The analysis will focus on risks and uncertainties from implementing the various pit reclamation alternatives.

4.1.1 Assumptions

The impact analysis is based upon the following assumptions:

- The Stage 5B pit mining and pit reclamation alternative would be fully implemented as described in Chapter 2.

- Potential mitigation has been built into each alternative as part of the activity that would occur under that alternative. The impacts described for each alternative are, therefore, the residual impacts left after the implementation of mitigating measures.
- Monitoring and maintenance of the water capture and treatment systems would occur under all alternatives as needed to meet the requirements of the Montana Water Quality Act and other permits. The amount of effort required to maintain the systems and the ease with which compliance is achieved may vary by alternative.
- Consequences of failure of each alternative will be estimated using the best available information. Risks and uncertainties will be noted.

4.2 TECHNICAL ISSUES

4.2.1 No Pit Pond Alternative (No Action)

4.2.1.1 Design and Constructability of the Alternative

Design and constructability of the No Pit Pond Alternative was not evaluated in the 1997 Draft EIS.

4.2.1.1.1 Proven Design

Under the No Pit Pond Alternative, 100 feet of crusher reject would be placed in the pit as a sump, and two to three 100-foot dewatering wells would be installed to the bedrock contact. It is estimated that 32 gpm would be pumped out of the wells (Telesto, 2003a).

As described in Section 4.2.1.3 and the pit backfill analog study (Gallagher, 2003c), pits have been backfilled by end dumping in Montana and elsewhere. Several pits in Montana and other states have been mined below the water table and have been partially backfilled above the water table level. Active dewatering has been conducted in partially backfilled pits.

It is technically feasible to haul backfill and install wells in a pit at closure. Backfilling by hauling to the bottom of the pit and end dumping and dewatering the pit under the No Pit Pond Alternative is a proven design. Backfill maintenance problems after construction of the alternative are described in Section 4.2.1.3.

4.2.1.1.2 Ability to Construct the Alternative at GSM

GSM would haul the crusher reject between 725 and 825 vertical feet down into the pit at closure from the eastern rim of the pit at the 5,350-foot elevation. GSM's safety policy would require special conditions such as truck load limits to be imposed during the backfill operations because of safety concerns with driving fully loaded trucks down the steep pit access road. The 5,700-foot elevation safety bench would have to be maintained. A 1.3-acre working surface would be created by the backfill. A safety berm would be installed on the working surface to protect workers and the dewatering wells.

Two to three dewatering wells would be constructed through the 100 feet of pit backfill to the bedrock contact. Drilling through unconsolidated waste rock is more difficult than drilling through solid rock but is done regularly using special equipment. Over 100 feet of backfill have been hauled into pits reclaimed in Montana and elsewhere. Dewatering wells pumping at least 32 gpm have been drilled in at least 100 feet of weathered acidic waste rock backfill at GSM and elsewhere (Gallagher, 2003c).

There would be minimal problems developing and implementing the No Pit Pond Alternative at closure as described because only 111,000 cubic yards (167,000 tons) of backfill and two to three wells would be needed. Pit highwall and dewatering well maintenance problems after construction of the alternative are described in Sections 4.2.1.2 and 4.2.1.5, respectively.

4.2.1.2 Pit Highwall

Ground movement in the mine area was analyzed in the 1997 Draft EIS, Chapter IV, Section IV.A.1.a. No changes affecting stability in the pit or waste rock dump complex areas have been identified since then. This section addresses both pit highwall stability and pit highwall maintenance requirements for the No Pit Pond Alternative. Additional geotechnical studies on pit highwall stability were conducted for this SEIS (Telesto, 2003d and 2003g). This section will concentrate on observations from over 20 years of mining at GSM and on new stability evaluations for the open pit area only.

4.2.1.2.1 Stability Observations at GSM Since 1981

During the past 20 years of open pit mining at the site, slope design studies have been performed (Golder, 1995a-l, 1996a, 1996b; Seegmiller, 1987, 1988, 1993; Telesto, 2003d, 2003f). Since before 1992, there have been several pit slope failures. Limited information is available on slides that have occurred. The following are volume and timeframe estimates for the slides (Telesto, 2003f):

- North highwall zone – 600,000 cubic yards in 1995 to 1997
- Southwest highwall – 500,000 cubic yards in 1999
- Upper west highwall zone – 200,000 cubic yards in 1999
- Southeast pit highwall – 10,000 cubic yards in 2001
- Expanded Ramp Pit Highwall – 50,000 cubic yards (Brawner, July 2002)
- Expanded Ramp Pit Old Pit Highwall – 10,000 cubic yards (Brawner, September 23, 2003)
- Northwest pit highwall – 310,000 cubic yards on August 31, 2004 where bedding planes that dip into the pit at 30 degrees intersected the Lone Eagle Fault. Movement in the area was being monitored prior to the failure.

These failures ranged from small scale bench and multi-bench failures to a large-scale wedge failure of the southwest highwall of the Stage 2 pit. These failures and smaller scale movements were a direct result of mining activities and ceased within days after mining operations moved to different areas of the pit (P. Buckley, GSM, personal communication, 2003). The largest contributing factors to these failures were conventional blasting, unfavorable structural orientations such as faults and or joint/ bedding planes that were exposed by mining, water pressure in joints and fractures, and vibrations from truck hauling, digging and dozing.

Highwall failures can be mitigated during operations using a variety of methods as follows:

- Mining to remove the area of concern.
- Flattening of the highwall in the area of concern to reduce the forces tending to cause movement.
- Buttressing the toe of the highwall to reduce forces that tend to cause movement.
- Providing artificial support such as rock bolts and dowels.
- Horizontal drain holes to reduce the hydrostatic pressure which tends to cause movement where unfavorable structural geology exists.

At times during operations, all of these methods or a combination of methods have been used to mitigate the impact of unstable sections of the pit highwall.

One factor influencing pit highwall stability that can potentially be controlled is the impact of blasting. Reducing over-break effects (i.e., fracturing and damage to the pit highwall beyond the extent desired for mining) leaves the inherent strength of the rock and geologic structures at the pit highwall in a stronger condition. Therefore, controlling the impact of blasting can be considered a pit highwall stabilization technique.

Pre-splitting is one of several techniques used to control over-break. Pre-splitting is similar to blasting techniques used in the rock quarry industry to remove blocks for building stone. With pre-splitting, a row of holes is drilled along the final excavation line and loaded with a special grade of explosive with reduced energy factors. These holes are fired prior to the production blast in an effort to create a fracture line and a reflective plane at the excavation limits. The idea of pre-splitting is to isolate the shot from the remaining rock formation by forming an artificial crack along the designed highwall. Although good over-break control results cannot be expected in all geologic formations, a carefully planned blast design can minimize over-break in even the most severe conditions.

Pre-splitting works well at GSM (P. Buckley, GSM, personal communication, 2003). Pre-split blasting techniques have been utilized since January 2001 and would be used throughout the remaining mine life of Stage 5B. Once mining activities for Stage 5B have been completed, approximately 58 percent of the pit highwall would have been mined by pre-split blasting techniques, from the 5,700 bench extending down to the 4,550 bench.

The impact of pit highwall instability during operations will range from minimal to the loss of a substantial portion of the ore reserve. For example, during mining of the Expanded Ramp Pit, two substantial highwall instabilities developed (see above). However, the mitigation for these did not result in the loss of ore reserves, although sections of the pit were redesigned.

Stage 5B would excavate several areas known for unstable ground conditions, however, a diligent slope stability program, including monitoring, geologic mapping, controlled blasting, dewatering, and scaling, would continue to mitigate poor ground conditions as they arise. This would reduce the likelihood of raveling and sloughing impacting long-term operations in the pit bottom. As an added safety measure, the safety bench located at the 5,700-foot elevation would separate the upper north highwall of the pit, where pre-splitting was not used, from the pit bottom. Most of the past failures were caused by, or were associated with, conventional blasting and digging activities. These failures would not be expected to occur after mining ceases.

The zones of past pit highwall instability that will remain after completion of the Stage 5B Pit are located above the 5,700-foot safety bench. Monitoring of these zones is on going and no impact from current mining has been recorded.

In summary, pit highwall instability has been largely attributed to mining activities intersecting unfavorable structures. Characteristically, ground movement has subsided within days after mining operations have moved away from the zone of instability. For this reason, these types of instability and frequency of occurrence would not be typical after closure at GSM, with any pit reclamation alternative being evaluated.

Based on over 20 years of observation, the slope failures that have occurred in the non-active mining areas of the GSM pit have been sloughing failures with localized raveling of benches (i.e., the benches lost their blocky shape). Outside edges of mine benches have broken off, and the intersection between the flat portions of the benches and highwall have filled with these rocks forming talus slopes. The impressions of the benches are still visually evident over most of the pit highwall. These failures have occurred predominantly during the spring and fall months following freeze and thaw cycles, spring melt of accumulated ice and snow on the pit highwall, and following large rainstorm events. These instabilities are typically small-scale and are similar to those observed on mountain slopes along highways.

Experience has indicated that raveling is more common on the newly mined pit highwall and would decrease as the pit highwall matures. On the south side of the pit, the pit highwall movement has been basically dormant for the past 10 years. Much of the north side of the pit, including a zone of instability on the northwest highwall, had been dormant for 6 to 10 years until failure occurred in 2004 (see above). Based on these observations over the mine's life, it is expected that raveling and sloughing would occur over time. The majority of raveling highwall rock would be caught on safety benches resulting in angle of repose surfaces less than 100 feet long and would not cause problems in the bottom of the pit. This type of instability would be slow in movement and progression, although occasionally rocks would fall off safety benches and roll to lower portions of the pit.

After closure, possible large-scale, multiple-bench wedge failures in Stage 5B that could destroy dewatering wells would be unlikely (Telesto, 2003d). This prediction is based upon the increase in the competency of the rock that is currently mined beneath the Corridor Fault and the resulting rock quality due to the current blasting methods implemented by GSM, which have decreased blast damage to the pit highwall. To further reduce the possibility of a wedge failure, GSM incorporates information regarding local bedding, faulting, and fractures directly into pit designs and excavation. Even with the predicted long-term stability, in this SEIS analysis, the agencies have assumed occasional failures in the following section.

4.2.1.2.2 Pit Highwall Stability

The results of the failure modes and effects analysis for the No Pit Pond Alternative in the 1997 Draft EIS, Chapter IV, Section IV.A.6.a indicated that most of the identified modes of failure have a low to very low probability of occurring. Moderately likely failure modes are primarily associated with potential block slip movements in the pit. The only failure mode that would likely occur is localized raveling of the pit highwall.

For this SEIS, GSM conducted an investigation into pit highwall stability for the proposed pit reclamation alternatives (Telesto, 2003d). The study focused on the Pit Pond Alternative, which has been dismissed in Section 2.5.4, and on the partial pit backfill alternatives. Because of the similarity in geometry between the Pit Pond and No Pit Pond alternatives, results for the Pit Pond Alternative are directly applicable to the No Pit Pond and Underground Sump alternatives and include a margin of safety.

For this investigation, rock and soil samples were collected to determine soil classification and geotechnical properties of the rock and soil, using standard industry accepted practices (Telesto, 2003i). The geotechnical properties were then used for modeling the reclamation alternatives for the GSM pit.

Block failure analysis was not conducted because the geology reports for GSM did not indicate the presence of a weak soil layer at the base of the slope, and because they indicate that most of the pit is constructed in an anticline (i.e., the formations dip away from the pit) (GSM, 1996c).

Circular failure analysis is more reasonable than block failure analysis because of the site-specific geology of the pit. Since the faults running through the critical cross-section are dipping back into the structure, the possibility of block failure is less likely than a circular failure. Although the major formations dip away from the pit, there are low lying bedding planes and joint faces that do dip into the pit especially on the northwest side. Pit highwall stability for each reclamation alternative was modeled using SLOPE/W v 5.04, a state of the art model for evaluating slope stability (GEO-SLOPE International, Ltd., 1991; Telesto, 2003d). The relationships between the pit highwall, faults, joints, and bedding angles are conducive to using the circular failure analysis, which overestimates the chance of highwall failures.

As mentioned in Section 3.2.2.2, stability analyses use factors of safety to estimate the inherent stability of the pit highwall. A factor of safety of 1.0 is considered stable. Factors of safety greater than 1.0 indicate higher pit highwall stability.

The model was run assuming Stage 5B without backfill and with the groundwater level still drawn down below the pit bottom as a result of operational dewatering (Telesto, 2003d). In the No Pit Pond Alternative, the pit would be backfilled with 100 feet of rock from 4,525 feet to 4,625 feet, which would reduce the overall height of the 1,875-foot-high highwall and increase the stability slightly. The water table would be maintained as close to the final pit bottom as possible, which would make it almost as stable as the dewatered Stage 5B Pit. The results of these failure analyses showed that the pit highwall would be stable, and the factors of safety would range from 1.17 (based on higher than anticipated input values) to 1.60 (based on expected analysis input values).

To be on the safe side, the Pit Pond Alternative was analyzed for stability because, with the highest water level and the least amount of backfill, highwall stability problems would be more likely to occur than with the other alternatives. The pit highwall stability for the Pit Pond Alternative following formation of a pit pond decreased from 1.17 to 1.16. The expected case remained at 1.60. A change of less than 0.1 in the overall factor of safety is not important considering the accuracy of this type of analysis. Based on these stability analyses, the factor of safety change would be negligible compared to the dewatered Stage 5B pit. This conclusion agrees with the results for the No Pit Pond Alternative in the 1997 Draft EIS.

The values for the pit highwall are less than the industry-accepted 1.3 short-term and 1.5 long-term factors of safety. However, there is a 97 to 99 percent probability that all the possible strength input parameters would be larger than estimated, resulting in higher factors of safety than calculated in the analysis. Therefore, the expected 1.6 factor of safety value is greater than the 1.3 short-term and 1.5 long-term factors of safety and should be considered as the expected factor of safety for the pit highwall.

Physical and chemical weathering of the pit highwall would not impose an immediate change to the geotechnical analysis presented (Telesto, 2003d). Short-term physical weathering of the highwall appears to be dominated by the effects of blasting, which do not extend far into the highwall, especially below the 5,700-foot safety bench where pre-split blasting has been used. Freezing and thawing would largely control pit highwall physical weathering rates over the long term. Chemical weathering from sulfide oxidation should not extend beyond a thin layer on the exposed surfaces of the highwall. Exposed sulfide-rich highwall rock in the pit would continue to oxidize through infiltration and percolation of precipitation and seeps regardless of the effectiveness of dewatering. Locally, the oxidation of iron hydroxide might enhance stability through iron oxide cement formation. Thus, physical and chemical weathering would not cause catastrophic failures in the pit highwall (Telesto, 2003d).

In addition to the circular failure analysis, Telesto (2003a) completed an addendum to provide discussion and historical perspective on the possibility of localized pit highwall failures not previously addressed by Telesto (2003d) that would likely occur after closure. The addendum discussed both failures that have occurred during mining operations and failures that can be expected to occur after closure. The addendum discussed the details of the geologic setting and previous pit slope failures at GSM since 1981.

Stability of the highwall after closure in a dewatered pit would greatly depend upon highwall rock integrity. Seeping and fractured areas would generally tend to be less stable unless secondary processes cause cementation of the materials in such zones. Pit highwall slopes would continue to undergo alternating periods of rock raveling and sloughing and quiescence for years after mining has ceased. As the pit highwall is acted on by gravity and the rock fracturing forces of freeze-thaw cycles, the steeper pit highwall would ultimately shed material to form talus slopes at its base, trending to an ever decreasingly steep highwall at the higher elevations. The 1,775-foot pit highwall should achieve equilibrium in 10 years or less after closure, with further minor adjustments in wet or above average freeze and thaw cycles and in years with earthquakes.

Seismic effects on stability were evaluated in the 1997 Draft EIS, Chapter IV, Section IV.A.1.a and no adverse effects on highwall stability were identified. No further evaluation of earthquake effects was made for this SEIS.

Mineralogical, geochemical, and geological data and observations were reviewed and analyzed relevant to the geotechnical evaluation of pit highwall stability at GSM after pit closure (Telesto, 2003d). The highwall stability at GSM has been compared to other sites with similar sulfide content. While the oxidation of sulfide and subsequent generation of acidic pore water can weaken the host rock, the geology and lithology of the host rock must also be considered when making such comparisons or predicting future stability.

Several factors at GSM indicate that physical or chemical weathering would not likely become a factor in highwall stability, as discussed in Section 3.2.2.3. Field and petrographic observations reveal that beyond a thin surface rind (less than 1 mm) of chemical weathering, the interior of the rocks is very fresh with no signs of incipient weathering (Telesto, 2003d). This thin rind can be seen on the rocks exposed to the atmosphere on the pit highwall as well as along natural and conventional blast induced fractures in the pit highwall. A disturbed rock zone caused by conventional blasting and mining can extend several feet to tens of feet into the pit highwall (Gallagher, 2003a; Paul Buckley, GSM, personal communication, 2003). Blast induced fracturing on the pit highwall may increase physical weathering, but has a limited effect on chemical weathering. Blast induced fractures and the near-surface consumption of oxygen combine to limit the expected extent of chemical weathering. The geotechnical testing of existing mine material indicates an acceptable factor of safety, and the data summarized above suggest that future physical and chemical weathering at GSM would not compromise overall highwall stability.

Although a direct analogy between the cause of weathering of the highwall and waste rock exists, a direct correlation between highwall weathering and weathering of the waste rock cannot be inferred (Telesto, 2003c). Waste rock in the dump complexes has weathered at a rapid rate (Herasymuik, 1996). On the highwall, physical weathering is minimized because the rock is left relatively intact after mining. In a few places in the pit where conventional blasting has caused more damage to the highwall, mostly along existing geologic structures, physical weathering has increased and resulted in localized failures. Because the waste rock has undergone a large amount of handling, such as blasting, loading, hauling, dumping, and spreading, more surface area has been exposed, and it is more susceptible to physical and chemical weathering. Larger rock fragments are placed within the dump and, in a relatively short period of time, break down into smaller particle sizes. The oxidation of the pyrite observed in the waste rock dump complexes has accelerated the break down of the rock. This accelerated chemical weathering has not been as pronounced in the pit rock on highwalls or on benches, which have had less physical damage. Thus, the lack of weathering observed on the highwall indicates that the highwall rock weathering rate is not directly correlated to waste rock weathering (Telesto, 2003c).

The 1998 ROD concluded that the highwall would be structurally stable under the No Pit Pond Alternative. Some raveling, talus formation, and limited sloughing of the highwall can be expected over the long term after mine closure. These occurrences would lead to increased stability of the highwall with minimal impact on the environment outside the pit area.

Under the modified No Pit Pond Alternative in this SEIS, the pit bottom would be deepened from 4,650 feet to 4,525 feet as part of Stage 5B. The effect of deepening the pit on highwall stability was evaluated and found to be minimal (Telesto, 2003d). The pit highwall angles, bench widths, and slope angles between benches would be left generally as shown in Figure 2-3. The bottom of the pit would be filled with 100 feet of backfill from 4,525 feet to 4,625 feet, reducing the maximum highwall height from 1,875 to 1,775 feet (Figure 2-3). GSM would use crusher reject material for sump material. The properties of the crusher reject material are described in detail in the groundwater effluent management system, Section 4.2.1.5.1. The backfill would act as a sump so that no pit pond is formed. As the groundwater levels surrounding the pit are drawn down during mining, and maintained following mining (HSI, 2003), the pit highwall would become more stable overall. This is because the fluid pressures within the rock mass, which act to destabilize the highwall, would be reduced (Telesto, 2003d). Small localized seeps would continue, especially along the Corridor Fault and other wet areas, largely in response to precipitation events (Gallagher, 2003b). These areas would remain locally unstable and are susceptible to additional chemical and physical weathering and raveling over time.

In summary, under the No Pit Pond Alternative in the 1997 Draft EIS, it would be expected that some portions of the pit highwall would be subject to raveling, talus formation, erosion, and limited sloughing, thus locally altering the configuration of some of the pit highwall. In particular, sloughing may be expected along the northwest area of the pit, where the orientation of existing faults renders the highwall less stable. As sloughing occurs, however, the overall stability of the pit highwall would be expected to increase over the long term as the rock materials achieve a more stable configuration. The combined effect of potential ground movement over time is anticipated to have negligible environmental consequences outside the pit area, but would impact access, maintenance, and dewatering system operation (Telesto, 2003d).

Under the No Pit Pond Alternative, 100 feet of backfill would have been placed to raise the pit bottom from 4,700 feet to 4,800 feet. The volume of backfill needed was estimated to be up to 500,000 cubic yards (750,000 tons) (1997 Draft EIS, Chapter II, Section II.B.6.b; 1998 ROD). The backfill would have created a working surface of 7.4 acres. In this SEIS, 111,000 cubic yards (167,000 tons) of backfill would be placed to raise the pit bottom from 4,525 feet to 4,625 feet. This would create a flat, dry working surface of 1.3 acres.

Due to the concerns over potential small-scale failures, a plan for monitoring and mitigation of slope movement of the pit highwall would be developed and implemented after closure. Inclinometers and survey prisms, which are currently used to ensure safe mining operations, would continue to be used to monitor ground movement in susceptible areas after closure. A plan concerning entry into the pit after a storm event or after long periods of absence would also be developed. These plans would help ensure workers' safety and provide a mechanism to maintain pit access.

Another potential cause of failure is surface water runoff from precipitation events. After closure, this potential would be minimized by storm water controls that would prevent an assumed 99 percent of storm water from entering the pit (Telesto, 2003a). This would be accomplished after final slopes are created and before mining is completed if possible. Otherwise, localized failures may occur increasing the amount of rock that ravels and sloughs onto safety benches and the pit bottom.

The term "risk" encompasses the concepts of both the likelihood of failure and the severity of the expected consequences if such events were to occur. An analysis considers both the risk of a failure and uncertainty in estimating the risk. This SEIS attempts to explain both the risk and uncertainties in the analyses that were conducted.

Likelihood categories are generally qualitative, however the use of numerical probability ranges to define the frequency of site specific events can provide additional guidance. Likelihood of failure was evaluated qualitatively for this analysis. In order to assess the impact or consequence of any potential failure on a system, potential receptors must be identified and characterized. Receptors vary at and within each mine site. Key receptors can include human health and safety; the environment; corporate reputation; community relations; government relations; and costs. Likelihood of occurrence and consequence are then evaluated to determine risk.

In the highwall stability analysis for each alternative, the agencies made assumptions of material quantities that could slough or fail over time. Although these quantities are not based on empirical data, as such data do not exist, they do provide a comparative analysis of alternatives. The assumed quantities of material may be subjective; however, the likelihood of such a failure occurring and the consequences of that failure do not change, and therefore the risk does not change. Technical information prepared for this SEIS was used in evaluating the risk involved with highwall stability issues.

Sloughing of the pit highwall was not as much of a concern in the 1997 Draft EIS because the working area would have been 7.4 acres in size, providing room for raveling and sloughing highwall rock, and the predicted failures would have been small over time. The 1997 Draft EIS and this SEIS analysis concluded that the risk of a large failure was low over time.

To address risk and uncertainty in this SEIS, the agencies have assumed failures would occur over time similar to those that have occurred during operations, as listed in Section 4.2.1.2.1. The agencies have assumed 100,000 cubic yards (150,000 tons) of highwall rock would ravel over time, especially on the northwest highwall, eventually covering the 5,700-foot elevation safety bench and rolling to the bottom of the pit. In addition, the agencies assumed another 100,000 cubic yards would slough into the pit from the northwest portion of the highwall, which would eliminate access to the bottom of the pit, bury the dewatering system, and cover the 1.3-acre working surface. To restabilize the pit, GSM would have to reestablish the safety bench at the 5,700-foot elevation, re-open the access road into the pit, haul more backfill into the pit to create a new larger working surface, and reestablish safety berms and the dewatering system wells. The agencies have assumed this could occur more than once over the long term. The agencies have assumed that, over time, highwall rock and backfill in the bottom of the pit would be 200 feet deep and total 600,000 cubic yards (900,000 tons).

As a contingency if the dewatering system was destroyed or became inaccessible, the agencies would require GSM to submit a plan for development, maintenance, and monitoring of a portal at a suitable elevation to allow access to the underground workings, so that dewatering would still be possible using the underground sump. Even with the assumed failures, there would be minimal impacts outside of the pit from periodic pit failures over the long term.

4.2.1.2.3 Pit Highwall Maintenance Requirements

As discussed under Pit Highwall Stability above, small-scale highwall instability would continue after closure under the No Pit Pond Alternative, which would affect pit highwall maintenance. Pit highwall maintenance requirements would be higher for alternatives that leave the pit open, such as the No Pit Pond and Underground Sump alternatives.

Highwall safety benches, especially the 5,700-foot safety bench, that are present during mining would remain in most areas and would catch most rock that ravels after closure. The pit haul road would have to be maintained for access. The highwall safety benches would have to be maintained to protect workers in the pit.

The agencies assume that safety benches would be compromised over time and that as much as 200,000 cubic yards (300,000 tons) of rock would ravel and slough to the bottom of the pit. This would require periodic maintenance to reestablish the 5,700-foot safety bench above the pit floor, clear the access road, haul more backfill to create a new larger working surface, and move rock to reestablish safety berms on the working surface. The agencies have assumed this could occur more than once over the long term, as described in Section 4.2.1.2.2.

4.2.1.3 Backfill

Large open pits have become a common part of modern mining operations. Although pit backfilling has not been required as part of MMRA and/or BLM's Surface Management Regulations, several mines in Montana have used backfilling to some extent. In Montana, some of the larger examples include:

- Montana Resources in Butte
- GSM near Whitehall
- Montana Tunnels west of Jefferson City
- Beal Mountain south of Gregson
- Basin Creek between Helena and Basin
- Zortman and Landusky in the Little Rockies
- CR Kendall near Hilger
- Treasure Mine northeast of Dillon
- Yellowstone Mine south of Cameron

Some pits have been backfilled in Montana by mining companies as part of regular mining operations when multiple pits were developed at one mining complex and it was a shorter haul distance to deposit waste rock. Some examples include:

- Montana Resources: The East Continental Pit was backfilled as part of the East Waste Rock Dump construction. The Pittsmont Dump was placed in the Continental Pit. The Pittsmont Dump may have to be removed again in future mining operations as ore still remains in the pit.

- Beal Mountain: The Main Beal Pit was partially backfilled during mining of the South Beal deposit. The pit was backfilled above the level of the water table with South Beal waste rock, and the high-sulfide rock in the lower

Main Beal Pit highwall was covered with South Beal waste rock and revegetated. The quality of the pit discharge slightly exceeds water quality standards. DEQ and the US Forest Service are monitoring the water discharging from the Main Beal Pit for water quality changes over time.

- Basin Creek: The Columbia Pit was backfilled during waste rock dump formation. The Paupers Pit was backfilled with the waste rock dump because of waste rock dump stability problems. The backfill is in the water table. The quality of the pit water, as well as local springs in the mineralized area, does not comply with water quality standards. DEQ and EPA are monitoring local springs in the area for potential increased water quality problems from backfilling the pit.
- Zortman and Landusky: Part of the Landusky Gold Bug Pit above the water table was backfilled during mining of adjacent pits.
- CR Kendall: The Haul Road Pit and the South Horseshoe Pit were backfilled with waste rock after the ore was mined out. Also, partial backfill of the Muleshoe and Kendall pits occurred during later mining of adjacent pits. The backfill material is above the water table.
- Yellowstone Mine: The South Main Pit and North Forty Pit were backfilled after the ore was removed and other pits were expanded. There is no water in the pit backfill material.

Other pits have been backfilled as part of reclamation conducted by the agencies after bankruptcy or settlement agreements. Some examples include:

- Zortman and Landusky: At Zortman, most of the pits have been backfilled to a free-draining condition to limit water needing treatment by diverting surface water off the backfill. The water table is beneath the bottom of the Zortman pits. At Landusky, some of the pits were backfilled to a free-draining condition. The water table level is in the backfilled portion of the Landusky pits. Most of the water is drained out of the Landusky pits backfill by an artesian well and the August Tunnel and is collected and treated. The volume of backfill placed into the Landusky Pits was limited by the quantity of non-sulfide waste rock available, plus the goal of capping the backfill as quickly as possible in order to minimize its exposure to precipitation. Despite the existence of underground tunnels and major shear zones beneath the Landusky pits, contaminant pathways could not be predicted with enough certainty to rely on pumping and treating to contain leachate from the backfill. Instead restrictions were placed on backfill material quality.
- CR Kendall: Some pits are being considered for backfill based on water issues related to the location of the waste rock dumps in drainage bottoms.

The water table is below the bottom of the pits. The feasibility of placing waste rock in the pit would have to be weighed against the advantages of removing it from the drainage bottoms. The water would be difficult to collect in the pits.

4.2.1.3.1 Pit Backfill Analog Study

A survey of existing open pit metal mines in the U.S., Canada and Sweden was performed to provide an "analog" to assist in evaluation of pit closure for those alternatives with partial pit backfill (Kuzel, 2003; Gallagher, 2003c). Information regarding other pit backfill projects was assembled utilizing many of the backfilled mines presented in the 1995 Mine Environment Neutral Drainage Program report (SENES, 1995). A total of 19 mines with potential pit backfills or pit lakes were initially contacted in 2003 (Kuzel, 2003). Information was gathered through telephone interviews and responses to written survey questions. Subsequently, emphasis was placed on mines with similar geology and climate, and that had a history of water quality monitoring (Gallagher, 2003c).

After screening the potential sites, three mines were chosen for more detailed evaluation, the San Luis mine in southern Colorado, Richmond Hill mine in the Black Hills of South Dakota, and the underground workings and Berkeley Pit at Butte, Montana (Gallagher, 2003c). None of the sites was a reasonable analog to the GSM pit backfill scenario. For instance, the San Luis pit has very different geology, the Richmond Hill backfilled pit is unsaturated, the Butte underground consists of saturated underground mine workings rather than a backfilled pit, and the Berkeley Pit is not backfilled.

No backfilled pit of comparable size was found. The San Luis pit was approximately 100 acres and 140 feet deep. The Richmond Hill pit was 35 acres and 150 feet deep. A summary of the pit characteristics and findings of the survey is provided in Table 4-1 (Gallagher, 2003c, as updated by the agencies).

Table 4 - 1 Summary of information for Golden Sunlight, San Luis, Richmond Hill and Butte mines[1]

	Partial Pit Backfill With In-Pit Collection Alternative -GSM	*San Luis, Colorado*	*Richmond Hill, South Dakota*	*Berkeley Pit, Montana*	*Butte Underground, Montana*
Pit size (acres)	*218*	*~100*	*35*	*~ 6752*	*About 10,0003 miles of tunnels*
Pit depth (feet)	*1,875*	*140*	*150*	*1,7802*	*Up to 1 mile deep*
Backfill amount (tons)	*50 million*	*5.78 million*	*3.5 million*	*N/A; pit lake ~900 feet deep*	*10-25 percent gob 4 and slimes*
Backfill depth (feet)	*775-875*	*140*	*<150*	*None except sloughing*	*N/A*
Geology	*Tertiary breccia pipe in Precambrian metasediments*	*Precambrian biotite-amphibole-quartzo-feldspathic gneiss*	*Tertiary breccia pipe in Precambrian amphibolites.*	*Quartz monzonite, quartz, enargite mineralization*	*Similar to Berkeley Pit with some unique mineralogy within individual mines*
% /Type sulfide	*Variable-average 1997 Draft EIS 0.5 to 2 percent pyrite in backfill*	*Range 0.49 to 5.43 percent as sulfur*	*Variable – average 1 percent – oxidized / 0-20 percent unoxidized zone pyrite and marcasite*	*Abundant pyrite, chalcopyrite, enargite*	*Abundant pyrite, chalcopyrite, bornite, chalcocite, covellite, digenite*
Period of Water Quality Data	*2002-2003 from in-pit sump*	*1997 to present*	*Pit backfilled – 1995; data through 2003*	*~20 years*	*~20 years*
Saturated/ Unsaturated	*< 100 feet Saturated/675-775 feet unsaturated*	*Both*	*Unsaturated*	*Saturated*	*Saturated (90 percent)*
Geochemical testing	*See Telesto, 2003c*	*Sequential Leach and humidity cell*	*ABA, NAG, whole rock, humidity cells, column leach test, mineralogy*	*N/A*	*N/A*

Predictions	*Poor quality leachate would form (Table 4-5)*	*Water quality degradation would not be an issue in backfilled pit*	*No water level rebound; no water quality impacts*	*Pit water level predictions; no change in water quality over time assumed in RI/FS[5]; water quality improving with age (Maest, 2003)*	*Water level predictions; no change in water quality over time assumed in RI/FS[5]*
Discharge from pit	*Assumed less than 10% of flow (1.5 gpm)*	*Seeps developed at contact of Rio Seco alluvium and pit backfill material*	*Seeps formed down gradient from unsaturated pit*	*Poor quality pit lake water (hydrologic sink has not reached critical water level; at that point 6.08 million gal/day would be pumped from the pit and treated[2]*	*Improvements in water quality after initial flooding, stable or declines in past several years. All discharges report to the Berkeley Pit hydrologic sink.*

[1] *From Gallagher, 2003c modified by the agencies*

[2] *Canonie, 1993.*

[3] *Duaime et al., 2004.*

[4] *Gob consists of low-grade ore/high-grade waste rock left in the mine tunnels during mining. The material was deemed uneconomic and therefore, was not brought to the surface. Montana Bureau of Mines and Geology personnel noted the tunnels contained much less than 50 percent gob and more likely 10 to 25 percent, although exact percentage fill is unknown.*

[5] *RI/FS – Superfund Remedial Investigation/Feasibility Study*

4.2.1.3.2 Backfill Maintenance Requirements

Settling in the 100 feet of backfill used for the sump would be 10 feet (Telesto, personal communication, September 2004) after a few years, as discussed in Section 4.2.1.5.2. Some additional settling could occur over the long term after large storm events or during snow melt if the water level rose in the backfill for a short time before it could be pumped back down. Continued chemical weathering of the crusher reject over time would also produce some settling as the rock weathers into smaller-sized particles from pyrite oxidation making it harder to dewater effectively.

Safety benches would have to be maintained to protect workers. Rock raveling off the highwall and escaping the safety benches and/or berms would have to be removed to maintain access. Periodic grading and dozing of the surface of the backfill may be needed to remove rocks that have raveled and sloughed. For information on soil cover maintenance requirements on the backfill working surface see Soil Cover Section 4.2.1.7.

The agencies have assumed 100,000 cubic yards (150,000 tons) of rock would ravel to the pit bottom over time. As discussed in Section 4.2.1.2.2, the agencies have assumed a 100,000-cubic-yard failure under the No Pit Pond Alternative, which could eliminate access to the bottom of the pit and destroy the dewatering system. If this were to occur, the water table would begin to rebound in the pit backfill. GSM would have to reestablish the safety bench, access, and the safety berm, and haul additional backfill into the pit to stabilize the material on the pit bottom and reestablish a safe, flat, larger working surface. Wells would have to be redrilled. The agencies have assumed this type of failure could occur more than once over the long term.

4.2.1.4 Underground Workings

4.2.1.4.1 Impacts to Pit Facilities Due to Subsidence Related to Underground Mining

Underground mining ceased in January 2004. The permit for the underground mine indicated that portions of the underground mine that break through into the pit or that might pose a hazard to work in the pit would be backfilled. As of June 2004, no underground workings have been backfilled. The current mine plan for the 5B pit includes mining to a safe distance from the underground stopes as determined by the GSM engineering department, backfilling the stopes, and then mining through the stopes. The stopes would be backfilled by blasting a raise into the stope and backfilling with rock material from the surface. At the end of the open pit mining, the location of the “C” stope would be evaluated to determine if it must be backfilled. However, this stope should be more than 100 feet from the pit highwall. The remaining stopes would be mined out by the 5B pit (Figure 2-2). Surface subsidence above the underground workings that are not backfilled would not be expected to occur (GSM, 2002a). During underground mining, rock stability was continuously monitored. Two years of monitoring information to date since underground mining operations began has not indicated any potential for subsidence or failure.

Based on the rock properties, design of the underground mine, monitoring and maintenance activities, and observations made during mining, subsidence of the underground workings is not expected to be a major problem. No monitoring of the underground workings is proposed for the No Pit Pond Alternative.

Localized failures of overhead rock over time, especially in the stopes, could result in subsidence, especially in seep and fault areas where chemical weathering would be increased. This subsidence could cause the 100 feet of backfill to settle affecting the dewatering wells in the backfill. The agencies would require GSM to replace wells that failed for any reason.

4.2.1.5 Groundwater/Effluent Management System

The principal goal of the No Pit Pond Alternative would be to maintain the pit as a hydrologic sink, keeping the groundwater level in the pit as close as possible to the final pit bottom at the 4,525-foot elevation. Regular pumping would prevent water quality from degrading further over time in the backfill. Precipitation, surface runoff, and groundwater seeps that drain into the pit would be removed by two to three dewatering wells and routed to the water treatment plant (GSM, 2002a).

4.2.1.5.1 Operation Requirements (Number of Wells)

The dewatering system would consist of two to three wells constructed through the 100 feet of crusher reject used for pit backfill to the bedrock contact. The permeability of the crusher reject is expected to be in the range of $1x10^{-3}$ cm/sec (Telesto, 2003e). Boreholes would be 10 to 12 inches in diameter and would be lined with 6-inch diameter Schedule 80 PVC casing. The bottom of the casing would be slotted. A stainless steel submersible pump equipped with electronic sensors to maintain optimum drawdown would be installed in each well. The water would be routed by pipeline to the water treatment plant prior to being discharged back into the ground, away from the pit area, in percolation ponds, LAD areas, or by other approved methods.

In addition, GSM would install horizontal drains in the highwall and incorporate these into the dewatering system as required to maintain safe operations. For existing operations, drains are located based on observation. The intent is to eliminate the potential for hydrostatic pressure in the highwall in areas of active mining. At closure, areas of the pit would be evaluated. If areas of the highwall were determined to be susceptible to hydrostatic pressure, additional hydrogeologic evaluations could be necessary to determine if drains were necessary. GSM personnel would conduct this evaluation, unless additional expertise was deemed necessary. Drains are currently used in areas of active mining (GSM, 2002a). The discharge would drain by gravity to the backfill sump, from which it would be pumped by the wells and transferred by pipeline to the water treatment plant. Dewatering also takes place from two existing highwall wells (PW-48 and PW-49). The highwall wells are located on a pit bench at the 5,800-foot elevation. The wells are located at an elevation above the Stage 5B pit expansion, and therefore will not be affected during mining. Some road maintenance has been required in the past to remove rocks that have raveled down onto the bench. However, walking access for monitoring activities has never been lost. These wells would continue as required to release pore pressures in the open pit highwall to minimize the potential for highwall failure during Stage 5B mining. Figure 3-5 shows the location of the dewatering wells.

The feasibility of pumping from 100 feet of backfill was not investigated in the 1997 Draft EIS. The No Pit Pond Alternative calls for backfilling the bottom 100 feet of the pit with approximately 111,000 cubic yards (167,000 tons) of crusher reject from the 4,525 to 4,625-foot elevation. The crusher reject is expected to have the durability and uniformity to provide an adequate permeability over time. The permeability was estimated at 1×10^{-3} cm/sec (Telesto, 2003e). East Waste Rock Dump Complex waste rock has been tested, and the permeability is 1×10^{-3} to 1×10^{-5} cm/sec (Telesto, 2003d). The reduction in permeability is due to chemical weathering of the waste rock.

The acidic pit backfill groundwater could cause corrosion of dewatering system components, as discussed below in Section 4.2.1.5.2. Redundancy would be necessary to ensure continuing operation of the dewatering system. One well can easily handle the anticipated pumping rate of 32 gpm. While mining Stage 5A, GSM pumped all of the pit inflow, generally from 10 to 30 gpm, from a sump at least 100 feet deep into waste rock in the pit bottom utilizing a single cased well. In order to ensure continuous operation, one additional standby well would be required. A third well would only be required if the one operating well and one standby well were to fail.

4.2.1.5.2 Maintenance of Capture Points

Under the No-Pit Pond Alternative, two to three wells would be used to remove acidic water from 100 feet of acidic backfill. Several problems could affect maintenance of these wells over time, including highwall raveling and sloughing, settling, corrosion, scaling, and potential biofouling. The agencies are concerned with maintaining the ability to dewater the backfill, prevent an acidic pond from forming in the bottom of the pit, and prevent discharges from the pit.

As described in Section 4.2.1.2.2, gradual raveling of highwall rock and occasional failures over time would cover the safety bench at the 5,700-foot elevation and would allow some highwall rock to reach the pit bottom. Some of the rock may overtop the safety berm and make it to the pit floor flat working surface and dewatering system. Damage to the wellheads, monitoring equipment, power lines, pump stations, and/or to the pipelines routing water out of the pit along the access road to the water treatment plant would occur.

The physical integrity of dewatering wells could be threatened due to settlement and consolidation of the 100 feet of pit backfill. Settlement of the backfill could impair the integrity of the well casings due to buckling, separation, or shearing. It could also cause bends or kinks in the casings that, although less severe, may prevent or impair access to the pump for maintenance and operations. About 70 percent of this settlement, 7 feet, would occur during the backfill operation and 30 percent, 3 feet, over a longer period after backfilling is complete (Telesto, personal communication, September 2004). This could affect well casing integrity and require replacement over time.

The corrosion potential of projected pit water quality was evaluated by Telesto (2003e). Three sources of water quality data were evaluated: pit seeps, 2002 to 2003 pit sump water, and the Midas Spring discharge out of the northeastern part of the East Waste Rock Dump Complex. The average pH for these three sources was 3.6, 3.4 and 2.3, respectively. The Langelier Saturation Index (LSI), which is widely applied in the estimation of a water's potential to either corrode or scale equipment, was utilized to evaluate corrosion potential (Grove, 1993). The LSI rating scale ranges from -5 for “severe corrosion”, to 0 for “balanced water”, to +5 for “severe scaling”. The lower and upper 90-percent confidence intervals for the pit seepage and pit sump waters produced LSIs of -7 to -4. The average Midas Spring water quality had a LSI of -7.3.

The corrosion study concluded that the expected water quality from East Waste Rock Dump Complex waste rock would be more corrosive than water quality in the pit sump measured from 2002 to 2003. The agencies assume that the crusher reject used in the No Pit Pond Alternative would be similar. The expected LSI (-5 or less) would result in severe corrosion potential if water is not pretreated. Under the No Pit Pond Alternative, no pretreatment is proposed prior to pumping from the pit. Stainless steel pumps would be used, but because of the low LSI of the backfill water, their life expectancy would be shorter than that of dewatering pumps used in 2002 to 2003 pit backfill dewatering operations. Stainless steel well casings were predicted to have a lifespan of only a few months (Telesto, 2003e).

Acidic water could produce iron hydroxide scaling as well as bacterial biomass, i.e., biofouling. This scaling would plug pumps, pipes, slotted casings, etc. and would shorten the functional life of wells. The low LSI rating for predicted pit water quality indicates scaling would not be a problem. GSM has reported limited problems with scaling over the life of the mine (GSM annual reports).

Standard corrosion potential modeling using LSI does not include biofouling potential. Problems from biofouling of wells and pumping equipment are expected to be minimal due to the low pH of the water. Biofouling becomes more of a problem as the pH increases above 4.5 (Cullimore, 1996). The basis for this prediction comes principally from experience at GSM and review of the literature on causes, prevention, and limiting factors (Telesto, 2004).

4.2.1.5.2.1 GSM Experience with Dewatering

Pit reclamation alternatives being considered for pit closure at GSM include long-term pumping of water from wells of various depths. In some alternatives, wells would be installed through the backfill to the bedrock contact and routinely pumped to maintain the water level in the backfilled pit at an acceptable minimum elevation. In another alternative, additional wells would be installed and operated down gradient of the pit. These wells would be similar to existing pumpback wells south of the GSM facilities. For the SEIS, Telesto performed several feasibility analyses regarding well performance based upon projected water quality of the backfill (Telesto, 2003e). The potential effects of biofouling on well performance were evaluated (Telesto, 2004).

GSM has operated dewatering systems at the mine for a number of years. These systems have been utilized in different scenarios. The following discusses the potential problems that can occur with pumping wells, including corrosion, scaling, and biofouling, and summarizes GSM's experience in operating dewatering systems.

4.2.1.5.2.1.1 Background

Although several factors can affect well performance, the items of greatest concern in the SEIS are settling and corrosion. Depending on pH, scaling and biofouling could be problems. GSM has dealt with each problem in different areas of the site during pumping activities.

The physical integrity of dewatering wells can be threatened due to settlement and consolidation of the material where the well is installed. Settlement can impair the integrity of the well casings due to separation, buckling, or shearing. It can also cause bends or kinks in the casings that may prevent or impair access to pumps for maintenance and operations.

Corrosion can limit the useful life of wells in a number of ways, including enlargement of screen slots, followed by sand pumping; reduction in strength, followed by failure of well screen or casing; deposition of corrosion products, blocking screen openings; and inflow of lower quality water caused by corrosion of the casing (Driscoll, 1986). Corrosion can result from chemical or electrochemical processes. Plastic or stainless steel is typically utilized to reduce corrosion problems in wells.

Scaling can be a major cause of well failure. Water quality chiefly determines the occurrence of scaling (Driscoll, 1995). The kind and amount of dissolved minerals and gasses in water determine their tendency to deposit mineral matter as scale. During pumping, velocity induced pressure changes can disturb the chemical equilibrium of the groundwater and result in the deposition of soluble iron and manganese hydroxides. A coating of iron hydroxide can build up, particularly if pumping is started and stopped intermittently.

Biofouling by iron-fixing bacteria is a common problem in wells worldwide. In general, iron-fixing bacteria gain energy by enzymatically catalyzing the oxidation of ferrous iron to ferric iron. The bacteria then use the energy gained from the oxidation process to reproduce, sometimes exponentially, resulting in a slime-like coating that may contain ferric hydroxides, ferric oxy-hydroxides, and hydrated ferric hydroxides. The slime precipitate can cause plugging of well screens and sand packs, rendering a well practically useless in a short time period. The introduction of iron-fixing bacteria into a well is not always certain. The bacteria may exist in-situ before the well is completed, or they may be carried in on drilling equipment or in drilling fluids that were exposed to the atmosphere prior to drilling. Regardless, iron-fixing bacteria are prevalent in the environment (Driscoll, 1995). Some species prefer circumneutral pH ranges, while others do well in low pH conditions.

GSM has operated dewatering systems in different scenarios. GSM has previously operated or currently operates wells or dewatering systems in the pit highwall, the pit bottom, the underground workings, down gradient of the tailings impoundments, the Midas Spring area, and in waste rock dumps. The following discusses experience in operating each of these systems.

4.2.1.5.2.1.2 Highwall Wells

Two highwall wells (PW-48 and PW-49) within the pit are regularly pumped to intercept groundwater from the Corridor Fault area before it enters the pit. The wells are located on the 5,800-foot-elevation bench of the north highwall. PW-48 was completed to 925 feet (perforated interval 851-925 feet); and PW-49 was completed to 455 feet (perforated interval 415-455 feet). PW-48 and PW-49 were constructed in July 1997, but were not regularly pumped until October 1999. These wells produce a combined flow of approximately 17 to 20 gpm.

Water quality in PW-48 is typically better than pit water, indicating the well is mostly intercepting regional groundwater. However, during high precipitation events, the water quality declines. During 2003, the pH of well PW-49 remained above 5. However, the water is acidic and has high levels of metals, such as iron and manganese.

Some maintenance is required for operating these wells. Flowmeters plug quickly and have to be maintained on a regular basis. Flowmeters are the largest maintenance item related to the highwall wells, as they become plugged with iron and other scale. This most likely is due to iron scale forming on the well screens and casing and then being pumped from the well. Because these wells are not vital to the actual dewatering operation, temporary down time is not typically an issue. The pumps have not been pulled and replaced since 1999, and have continued to operate. Since the pumps have not been pulled, it is not possible to evaluate if scaling has affected well efficiency to a large degree. However, flow rates have decreased little over time.

As these two wells are constructed in the bedrock in the pit highwall and the pH of the water is about 5.0, their operation is not indicative of what would be expected to occur in wells installed in backfill material with a pH ranging from 3.0 to 4.3, but could be indicative of potential wells installed in bedrock down gradient of the pit.

4.2.1.5.2.1.3 Pit Dewatering Well

The pit dewatering system used in 2002 to 2003 consisted of a dewatering well in approximately 185 feet of backfill, a 15 hp stainless steel submersible pump, booster station, and associated piping and storage structures in the pit. The dewatering well was constructed in a combination of crusher reject and rock previously pushed into the bottom of the pit from higher benches. The well was an HDPE pipe with slots. Water was allowed to collect in the backfill material, and the well was pumped periodically to keep the water down to an acceptable level for underground and open pit mining activities, below the current pit bottom. Piping consisted of HDPE and PVC.

The average pH of the water pumped from the pit during 2002-2003 was 3.6. This well was utilized for a period of approximately 10 months.

The largest maintenance issues involved deterioration of PVC pipe sections, float switches, and centrifugal pumps at the booster station due to the low pH of the water. In addition, plastic parts occasionally were affected by heat due to the pumping scheme. When dewatering was occurring on a continuous basis, approximately 20-30 hours per week were spent on the dewatering system maintenance, which included the pit dewatering well and highwall wells. Stainless steel parts did not deteriorate during the active life of this well. No biofouling problems were identified when the pump was removed and the well was mined out. During the 10 months, pumping rates were not reduced from either well screen or pump intake clogging. When the pump was removed, it had no scale or slime growth on it. In addition to low pH water, another key factor for preventing or minimizing biofouling is to limit the aerobic/anaerobic interface near well screens and pump intakes. By proper well design and pump operation the water level can be maintained above the screens and water entry velocities kept low, which may limit biofouling. As the hydrology of the system becomes more complicated, this becomes more difficult to accomplish.

Problems were encountered with the lowest portion of the well silting in. This was most likely due to the slot size and the fact that the well was not installed with a gravel pack. The pump was periodically raised in the well casing to alleviate this issue.

Operating issues that occurred during this time would be expected to recur under the No Pit Pond Alternative. Due to the weathered waste rock being placed in the pit and depth of backfill in the Partial Pit Backfill With In-Pit Collection Alternative, the issues could be compounded. Given the likelihood of elevated iron concentrations in the water to be pumped from the potential backfill, and the "omni-presence" of iron-fixing bacteria, biofouling of backfill wells is possible if the pH rises. Treatment of biologically fouled wells typically includes some type of oxidant (e.g., chlorine, bromine) to break down the cell walls of the bacteria. Oxidants also can precipitate oxides of many metals. Given the high metals concentrations projected in the backfill, the introduction of oxidants could create other problems, such as lower pH in the well and chemical precipitation that could induce further well fouling. Thus, the ability to treat a biologically fouled well may be impaired by the physical and chemical conditions that would be present.

In the event biofouling occurred as determined by production loss or pump/well inspection, there are a number of rehabilitative processes, which could be tried short of constructing new wells. The best would be to high-pressure water jet the screen with subsequent well flushing. Another would be to chemically oxidize any bacterial growth. New methods, which could also be tried, use a combination of treatments such as dispersants, pH modifiers, and disinfecting agents. Biofouling is not expected to be a major problem because of the low pH of the pit water. Biofouling has not been a problem at GSM during operations. Therefore, biofouling is not expected to be a problem in water treatment after mining.

4.2.1.5.2.1.4 Underground Dewatering

The pit dewatering system used during underground mining consisted of a sump in the underground workings to drain and collect pit water. Water in the pit flowed into the underground workings through drill holes connecting the bottom of the pit with the underground workings. The underground mine has a sump with an approximate 500,000-gallon capacity at an elevation of approximately 4,650 feet. Any water that collected in other areas of the underground workings was pumped to this sump. Water was pumped from the underground sump through a 3-inch HDPE line to the 4,700-foot booster station. From the 4,700-foot booster station, water was pumped to the 4,850-foot booster station, and then to the 5,000-foot bench booster station through 4-inch HDPE lines. Finally, the water was pumped out of the pit from the 5,000-foot bench booster station, through a 4-inch HDPE line, to a lined holding pond below the mill.

In 2003, the pH of the water pumped from the underground workings ranged from 3 to 4.3. The water contained high levels of metals such as iron and manganese. No corrosion problems occurred with the underground dewatering equipment despite predictions based on the LSI rating. Problems were encountered with the booster pump system, as described for the pit dewatering. The quality of water extracted from the underground workings is expected to be similar to that observed for the current seeps. Based on previous experience, stainless steel pumps and parts may have a reasonable life expectancy.

Since the cessation of underground mining in February 2004, water has collected in the underground workings. This water still flows to the underground workings through drill holes connecting the pit bottom with the underground workings. No water has been removed from the underground workings since the cessation of underground mining.

Operating issues that occurred during this time would be expected to be similar to the Underground Sump Alternative and not the No Pit Pond Alternative. However, due to the contact time between the water and the pit rock, the ultimate water quality would not be expected to be good (Table 4-5).

4.2.1.5.2.1.5 Groundwater Pumpback Wells

GSM operates a large number of pumpback wells south of the tailings impoundments (Figure 3-5). The four Rattlesnake Gulch wells are also pumped regularly above the Buttress Dump. The pumpback wells have been operated since the mid-1980s and early-1990s; the Rattlesnake Gulch wells have been operated since 1998.

The water quality in the pumpback wells is not similar to the pit area water. The Rattlesnake Gulch well water has an acidic pH, although not to the extent of the pit area water.

Operational monitoring of the pumpback wells ensures efficient operation of the active seepage control system. Flow rates, dynamic and static water level measurements, and regular maintenance are key elements to this monitoring. The pumpback well systems have totalizing flowmeters that are normally checked twice per month to determine monthly average flow rates. Monitoring wells are associated with each group of pumpback wells. GSM inspects all of the operating pumpback wells daily. Lights, which serve as visual indicators, have been installed on each operating well. If operational checks indicate a deviation from normal operation, maintenance personnel are advised immediately. Proper operation of these wells is important; therefore, any required mechanical/electrical inspection or repair work is done as quickly as possible.

The Rattlesnake Gulch wells were originally plumbed with steel and plastic pipe and fittings. Problems developed with pumps and plumbing at least every 3 months. The system has been re-plumbed with Schedule 80 PVC and stainless steel. In addition, the flow rates in these wells have decreased. No major repairs have been required for approximately 1 year on the Rattlesnake Gulch wells. The pumpback wells were originally plumbed with steel pipe. Smaller pumps were installed in all of the wells, and all of the plumbing is currently Schedule 80 PVC.

Maintenance of the pumpback system is complex and time consuming. Maintenance activities currently consist primarily of pump replacement, hour meter repairs, and flowmeter repairs. Corrosion, scaling, and biofouling have not been problems recently. Some silting, sanding, and scaling in pumpback wells was noted in 1993 and 1995 (GSM 1993 and 1995 annual reports). Approximately three pumps are replaced per year. As the aquifer continues to be dewatered, well yield decreases, and in some cases the wells dry up. As the well yield decreases, smaller pumps must be installed in the wells.

The entire pumpback well system was redone in 2001. GSM completely refurbished the east flank pumpback wells and the south pumpback wells, which included a total of 48 wells. The work consisted of setting up on each well, pulling the original column pipe and pump (2-inch steel pipe, 5 to 7 horsepower pump), blowing debris from the well using compressed air, and cleaning the screen. Once the well was redeveloped, appropriately sized new pumps were placed in the wells. One-inch PVC pipe was used instead of steel for easier maintenance. Equipment required for the project included a pump truck, air compressor, and associated equipment. Daily monitoring of these wells takes approximately 2 hours per day. Approximately 20 hours per month are typically spent on maintenance activities for these wells.

Operating issues similar to these wells could be expected for the Partial Pit Backfill With Downgradient Collection Alternative.

4.2.1.5.2.1.6 Midas Spring

The Midas Spring capture system is located below an area formerly occupied by a small slump and spring. To prevent groundwater from contacting dump material, a portion of the spring area was previously excavated, and a gravel drain and piping system was constructed in early 1994 to intercept shallow groundwater and lower the potentiometric surface beneath the dump complex. Presently, acidic discharge from the Midas Spring is captured in a series of drains beneath a portion of the East Waste Rock Dump Complex. The drains route the water to a collection tank/pumping system, where it is then pumped via pipeline to the water treatment holding pond in upper Rattlesnake Gulch. This water is then blended with water pumped from the open pit and treated in a lime-precipitation treatment plant located in the mill complex.

The Midas Spring water is poor quality. The Midas Spring was impacted when it was covered with waste rock (in the East Waste Rock Dump Complex) during the early stages of mining at GSM. This spring also has a unique geologic setting in that it is located in an area with structurally controlled high sulfide mineralization, elevated iron, silver, and copper, deep oxidation, and a surface seep influenced by a landslide/debris flow. Therefore, water from the Midas Spring is considered to represent “worst-case” seepage from waste rock dump material.

Stainless steel submersible pumps used to pump water from the Midas Spring to treatment have to be replaced at least every 6 months. There are times when a pump may only last 2 weeks due to failure of pump and motor components, which are not stainless steel. Pumping of solids most likely also affects the life of these pumps. The manifold lines have to be cleaned at times due to solids building up in the line. In addition, sludge that accumulates in the tank has to be removed periodically.

GSM and EPA conducted a research project on the Midas Spring during which the spring was diverted into a lined pond filled with crushed limestone. The limestone became plugged within a year and a half, and the research project was discontinued.

Some of the operating issues with the Midas Spring system could be expected to occur for the Partial Pit Backfill With In-Pit Collection Alternative.

4.2.1.5.2.1.7 Waste Rock Dump Testing

GSM has conducted research and monitoring activities in waste rock dumps for a number of years. Some of this work included installation of monitoring wells and other tubes into waste rock material. The wells were more difficult to install than wells in solid rock formations.

For research conducted on the unsaturated West Waste Rock Dump Complex, several 2-inch steel pipes, up to 175 feet long, were drilled into the weathered material for data collection (Schafer and Associates, 1996). After a few years, acid generated by sulfide oxidation coupled with some shifting in the waste rock resulted in blockage of the deepest pipe. Efforts to clear the pipe were unsuccessful. Shallower PVC pipes were also installed up to approximately 70 feet deep. Schafer and Associates (1996) noted that minor movements of waste rock deformed these access pipes, preventing sample acquisition at several sites during the first year of operation.

Some problems have been encountered with monitoring wells in the West Waste Rock Dump Complex. One well has sanded in, and another well was damaged during reclamation activities. Another well appears to have a separated casing, but this is unconfirmed. A damaged well in the area near the pit was replaced in 2004 possibly because of ground movement.

Operating issues encountered during monitoring in waste rock dumps could be expected to occur for the Partial Pit Backfill With In-Pit Collection Alternative.

4.2.1.5.2.2 Dewatering Experience at Other Mines

Mines have not typically been required to dewater backfill, so there are few examples. There are no mines with similar amounts of backfill as described in the partial pit backfill alternatives (Gallagher, 2003c). At the San Luis Mine in Colorado, which has a maximum depth of about 140 feet of backfill, about one in five pumps fail due to shifting backfill, which deforms the installations. Precipitation and clogging of well screens in ARD plumes have affected wells at the Climax and Grasberg Mines.

Groundwater has been a concern in the Butte Mining District ever since the early mineshafts encountered water at depths of 20 to100 feet below ground level. To allow underground and open pit mining in the area, the groundwater level was lowered by pumping. Prior to cessation of open pit mining in the Berkeley Pit in 1982, dewatering was occurring at a rate of 4,000 to 5,000 gpm. The pumping system was located in the Kelley Mine Shaft west of the Berkeley Pit from the 1960s to 1982 (Canonie, 1994). Dewatering from underground sumps allowed underground mining in Butte for almost 100 years. Pumping from the underground workings for over 20 years effectively lowered the water table during open pit mining.

Montana Resources has pumped water from a floating barge in the Berkeley Pit to recover copper in the precipitation plant with minimal operational problems (S. Czehura, Montana Resources, personal communication, August 2004).

In summary, several factors could affect maintenance of the dewatering wells. The agencies would require GSM to install and maintain a remote monitoring system for wells, pumps, pipelines, powerlines, etc. to minimize the need for workers to be in the pit and to ensure water is kept as low as possible in the backfill. GSM would have to replace any wells that failed.

4.2.1.6 Storm Water Runon/Runoff Management

Surface water runoff from storms and snow melt would be diverted around the open pit. As part of the final reclamation of the site, GSM would construct permanent storm water controls concurrently with site reclamation. As described in Section 2.4.2.5, storm water diversions designed to carry the flow from a 100-year storm event would be constructed around the pit perimeter to prevent as much surface water as possible from entering the pit. The storm water diversions would be designed and sized, installed to grade, lined with a geosynthetic liner to reduce infiltration into the pit rock under the diversions, covered with 3 feet of soil and/or riprap depending on location and the design flow of the diversion, and revegetated where appropriate.

The only storm water that would enter the pit would be direct precipitation on the pit disturbance area and runoff from areas where diversions would not be possible due to topographic constraints. It is estimated that 99 percent of the storm water around the pit area could be diverted away from the pit (Telesto, 2003a).

4.2.1.6.1 Maintenance Requirements

The maintenance requirements for the diversions would include regular monitoring of the system integrity and gradient to ensure proper function.

Some settling may occur where the diversions are constructed on unconsolidated materials, which would affect the ability of a diversion to route water away from the pit area over time. If the gradient changed from settling resulting in low spots, the diversion would have to be returned to the proper gradient, resoiled and seeded as necessary. Eventually, portions of the diversions would need to be reconstructed completely or at least have sediment accumulations and/or rockfalls from upgradient slopes removed. If 99 percent of storm water cannot be diverted, the amount of water needing treatment would increase.

4.2.1.7 Soil Cover

4.2.1.7.1 Soil Cover Maintenance Requirements

As described in Section 2.4.2.6, GSM has proposed a 3-foot soil cover on the pit floor area, pit benches, and roads, totaling 53 acres of revegetation. Seven acres have already been revegetated in the pit. Another 68 acres around the pit would be reclaimed with 3 feet of soil and revegetated. Any acreage revegetated in the pit would need to be monitored for rock raveling and sloughing, backfill settling, erosion, and noxious weeds. Rock that has raveled or sloughed would have to be removed or covered with new soil. Areas that have settled would have to be filled to grade with additional soil. Eroded areas would need to be repaired, resoiled and reseeded. Noxious weeds would have to be controlled. One hundred fifty-eight acres would not be resoiled in the pit.

Any rocks off the highwall that escape the safety benches may end up on the soil covered revegetated area. These areas may either need to be cleared or resoiled and reseeded.

As described in Section 4.2.1.3.2, some grading and/or dozing of the backfill surface may be needed if the backfill settled. This would affect the soil cover and more soil would have to be placed and reseeded.

As described in Section 4.2.1.2.2, the agencies have assumed the pit bottom would eventually be covered with rocks raveling off the highwalls and/or highwall rock from sloughing. The soil cover would be covered with the rocks. GSM would have to haul more backfill to reestablish the flat working surface and haul in new soil and reseed the soil.

4.2.1.8 Water Treatment

The 1997 Draft EIS, Chapter IV, Section IV.B.6.e and Appendix A evaluated the water treatment system for all water pumped from the pit. The treatment plant would be a standard lime treatment system located below Tailings Impoundment No. 2 (Figure 1-2). This system would be similar to the water treatment plant operating at the Berkeley Pit in Butte. The 1998 ROD approved the water treatment plant with a design capacity, including contingencies, of 392 gpm, which included the 102 gpm of pit seepage then projected for the No Pit Pond Alternative. No changes to the treatment system have been proposed since the 1998 ROD. The treated pit water would be disposed of in a percolation pond below Tailings Impoundment No. 2. The revised pit water balance completed for this SEIS identified that 32 gpm would have to be pumped to the treatment plant under the No Pit Pond Alternative.

The1997 Draft EIS assumed that the pit would not discharge into surrounding aquifers. Total water collected and treated, with contingencies, from the East Waste Rock Dump Complex was predicted to be 25 gpm and from Tailings Impoundments No. 1 and No. 2 was predicted to be 225 gpm in the 1997 Draft EIS, Appendix A, Table 2-1.

Table 4-2 compares 1997 Draft EIS inflows to the water treatment with SEIS predictions. In the No Pit Pond Alternative in this SEIS, total water needing treatment would be 260 gpm compared to 392 gpm in the 1997 Draft EIS. The water treatment plant is designed to handle this amount of water. The agencies would bond for 392 gpm as a contingency in case inflows are more than predicted.

Table 4 - 2 Water Treatment Plant Inflows (gpm) for the No Pit Pond Alternative

Facility	1997 Draft EIS[1]	SEIS
Tailings Impoundment No. 1	200	105
Tailings Impoundment No. 2	25	25
West Waste Rock Dump Complex	77	77
East Waste Rock Dump Complex	25	21
Pit	65	32
TOTAL	392	260

[1] 1997 Draft EIS, Appendix A, Table 2-1; volumes include contingencies

4.2.1.8.1 Additional Sludge Management Requirements

The new water balance completed for this SEIS concluded that only 32 gpm from the pit would need to be treated under the No Pit Pond Alternative. The quality of the water assumed to be treated in the 1997 Draft EIS was not as poor as that assumed to be treated in this SEIS (See Section 4.3.3.1.1.2.1 and Table 4-5). More sludge would be produced per gallon of treated water.

About one-third the volume of pit water would be treated, so the sludge management requirements would be similar to or less than those evaluated in the 1997 Draft EIS, Chapter IV, Section IV.B.1.e.

4.2.1.8.2 Additional Operating Requirements

The water treatment system in this SEIS is the same as that evaluated in the 1997 Draft EIS, and as shown in Table 4-2 there would be less water to treat from the pit.

There would be no additional operating requirements under the No Pit Pond Alternative from those analyzed in the 1997 Draft EIS.

4.2.1.9 Flexibility for Future Improvements

The flexibility for future improvements and potential for utilization of new technologies was not evaluated in the 1997 Draft EIS for pit reclamation alternatives. GSM and the agencies believe this is an important issue because of the risks and uncertainties associated with backfilling the GSM pit.

4.2.1.9.1 Potential for Utilization of New Technologies

As stated above in Section 4.2.1.5.1, 32 gpm of water would need to be treated under the No Pit Pond Alternative. The water would be pumped out of 100 feet of acidic backfill. As described in various sections above, this can be done although it would be more difficult in weathering, unconsolidated, settling, acidic waste rock than native, unweathered rock.

The acidic water would require regular maintenance and replacement of pumps and other dewatering well components, as discussed in Section 4.2.1.5.2.

GSM has been researching the potential to treat or at least pretreat pit water in situ. During pumping from the pit sump in 2002-2003, GSM added carbon sources such as alcohol and sugars to the pit in an attempt to pretreat the pit water in the rubble at the bottom of the pit. The test was partially successful in improving pit water quality (GSM 2002 annual report). GSM has initiated a new test during the mill shutdown (GSM, 2004). This new test has been approved by the agencies (DEQ and BLM, 2004). Pretreating the pit water would increase the operational life of dewatering system components by reducing corrosion.

Research is being conducted on treating pit water with carbon sources, microbes, etc. in various locations around the world, for example the Berkeley Pit in Butte and Gilt Edge Mine in South Dakota. If an alternative to pumping and treating were developed in the future, it would be easier to pretreat pit water in an open body of water than in waste rock. It is easier to pump and mix carbon sources, microbes, etc. evenly in an open body of water than in saturated waste rock backfill.

If pit water had to be treated in saturated backfill, it would be easier to treat it in the less than 600,000 cubic yards of pit backfill and rock projected to fall to the bottom of the pit over time in the No Pit Pond Alternative than it would be in the much larger volumes of rock placed in the pit under the partial pit backfill alternatives.

4.2.1.9.2 Consequence of Failure of Dewatering System

If the dewatering system failed under the No Pit Pond Alternative, a pit pond would form. Pit water balance studies were completed for the Pit Pond Alternative, which was considered but dismissed in Section 2.5.4. These studies concluded that for the Pit Pond Alternative without pumping pit water, the water level would rise and stabilize at the 4,635-foot elevation with no discharge. The agencies believe that the results of the water balance studies performed for the Pit Pond Alternative have some applicability to the No Pit Pond and Underground Sump alternatives.

Under the No Pit Pond Alternative, no water would leave the pit through fractures. Thirty-two gpm would be expected to flow into the pit. With the volume of backfill and the volume of rock that would ravel and slough to the pit bottom over time, and without pumping, the water would rise above the 4,635-foot elevation and stabilize well below the 5,050-foot elevation. At the 5,050-foot elevation, water would start to leave the pit (Telesto, 2003a).

It would be easier to implement treatment systems using chemicals, carbon sources, microbes, etc. in an open body of water than in pit backfill.

4.2.2 Partial Pit Backfill With In-Pit Collection Alternative (Proposed Action)

4.2.2.1 Design and Constructability of the Alternative

4.2.2.1.1 Proven Design

As in the No Pit Pond Alternative, 100 feet of crusher reject would be placed in the bottom of the pit as backfill for use as a sump. Then under the Partial Pit Backfill With In-Pit Collection Alternative, the rest of the backfill would be hauled to the pit rim and end dumped to an average 5,400-foot elevation. Finally, the upper highwall would be reduced by cast blasting and dozing until the 2H:1V final slope was achieved. Four dewatering wells from 775 to 875 feet deep would be drilled on the 5,400-foot elevation backfill surface. It is estimated that 15 gpm would be pumped out of the wells (Telesto, 2003a). Seventeen gpm would be routed off the backfill as storm water runoff or would be used up through evapotranspiration.

As described in the No Pit Pond Alternative, Section 4.2.1.3 and the pit backfill analog study (Gallagher, 2003c) pits have been backfilled by hauling to the bottom and end dumping and by end dumping from the pit rim in Montana and elsewhere. Cast blasting is a common mining technique but has had limited use in reclamation. Cast blasting of the upper highwall as a reclamation technique to reduce portions of the highwall has been discussed at GSM, Zortman and Landusky (B. Maehl, personal communication, 2004), and proposed at the McDonald Gold project (Seven Up Pete Joint Venture, 1994).

It is technologically feasible to haul backfill, cast blast highwalls, and install wells in a pit at closure. Backfilling by hauling to the bottom of the pit and end dumping and by hauling and end dumping from the pit rim is a proven design. Cast blasting to reduce highwalls has not been used as much in regrading pit slopes but cast blasting is a proven design in and of itself. Dewatering a backfilled pit by installing wells is a proven design in shallow pits; it is not a proven design in deep backfilled pits, especially those with acidic water (HCI, 2002). For research conducted on the unsaturated West Waste Rock Dump Complex, several 2-inch steel pipes, up to 175 feet long, were drilled into the weathered material for data collection (Shafer, 1995a).

Backfilling and cast blasting are proven designs. It is technically feasible to backfill and cast blast, but the agencies have not documented any other pits the size of the GSM pit that have been backfilled by end dumping and cast blasted to reduce highwalls. Dewatering acidic backfill from this depth has also not been documented (HCI, 2002; Kuzel, 2003; Gallagher, 2003c).

4.2.2.1.2 Ability to Construct the Alternative at GSM

The pit backfill analog study conducted for this SEIS did not find any hardrock mine in which such a large pit was backfilled and allowed to become saturated with groundwater (Gallagher, 2003c). No long-term water quality monitoring records exist at the backfilled mines or flooded underground mines studied sufficient to indicate whether the reclamation goals at those mines were achieved.

As described in the No Pit Pond Alternative, crusher reject would be hauled to fill the bottom 100 feet of the pit. After the 100 feet of crusher reject has been placed under the Partial Pit Backfill With In-Pit Collection Alternative, GSM would start hauling and end dumping waste rock from the pit rim. End dumping would continue to an average elevation of 5,400 feet. Total backfill volume would be 33,300,000 cubic yards (50,000,000 tons). GSM is larger than the pits reviewed in the pit backfill analog study. Backfilling by end dumping could be accomplished and would take longer than the other pits studied. The environmental consequences are less predictable at GSM especially in a pit that has been mined below the water table and filled with acidic waste rock.

The upper 1,000 feet of the highwall would be reduced by cast blasting and dozing to create 2H:1V slopes. If cast blasting failed on any portion of the highwall, waste rock could be hauled and end dumped. Cast blasting would enhance the overall stability of the pit highwall but would disturb an additional 56 acres (Figure 2-4).

Installing dewatering wells at this depth in unconsolidated waste rock backfill and pumping the estimated 15 gpm of pit groundwater from this depth is more difficult than the same activities in 100 feet of waste rock and pumping the estimated 32 gpm under the No Pit Pond Alternative. The agencies believe that four dewatering wells could be installed successfully, although it would be difficult in 775 to 875 feet of backfill (J. Finley, Telesto, personal communication, 2003).

No actual case histories or examples of dewatering wells pumping as little as 15 gpm in up to 875 feet of weathered acidic waste rock backfill have been found (HCI, 2002; Gallagher, 2003c). The agencies believe that wells of this depth and capacity could be pumped successfully, at least initially, but wells and pumps would need regular maintenance and replacement.

There would be more problems developing and implementing the Partial Pit Backfill With In-Pit Collection Alternative than the No Pit Pond Alternative at closure because of the larger volume and depth of backfill needed, the amount of cast blasted material, and the problems drilling dewatering wells up to 875 feet deep in unconsolidated waste rock in order to maintain the pit as a hydrologic sink.

The agencies believe the dewatering wells would fail repeatedly over time due to settling and corrosion. In addition, it is doubtful that 15 gpm could be continually pumped from these wells from this depth without allowing time for the water table to rebound in the backfill sump (HCI, 2002). Therefore, water may not be restricted to the lowest level of the pit, which is the agencies' goal. Fluctuation in the water table would degrade the quality of the water and increase settling (Telesto, 2003e). The quality of the water in the backfill would result in problems with corrosion. Scaling and biofouling are not expected to be a problem because of the low pH of the pit water. The agencies would require GSM to replace dewatering wells that failed.

Waste rock samples show fairly high permeability for the projected pit backfill, based on 18 field samples from the surface and 5 laboratory samples from depths up to 15 feet (Telesto, 2003d). Sample results were similar to those reported by Herasymuik (1996). They were considered to be representative of the entire East Waste Rock Dump Complex. Herasymuik's maps and cross sections show that his sample pits were dug during re-excavation of the East Waste Rock Dump Complex after the 1994 ground movement. The samples were taken from under up to 100 feet of waste rock, and the waste rock was in place for only 5 to 6 years, under unsaturated conditions. The applicability of these results to conditions under a much greater thickness of fill, over an indefinite period of time, and under varying degrees of saturation, is uncertain The agencies believe that permeability would decrease over time due to compaction in up to 875 feet of backfill and accelerated weathering due to rehandling waste rock for backfill.

4.2.2.2 Pit Highwall

The stability analysis for the Partial Backfill Alternative is summarized in Appendix H of the 1997 Draft EIS. The analysis concluded that there would be no difference in overall pit highwall stability between an open pit and a backfilled pit. The only element of the Partial Pit Backfill With In-Pit Collection Alternative that would increase stability in comparison with the No Pit Pond Alternative in this SEIS is a change in the pit configuration due to cast blasting to achieve overall 2H:1V slopes in the highwall.

4.2.2.2.1 Pit Highwall Stability

Under the Partial Pit Backfill With In-Pit Collection Alternative, the pit from the 4,525-foot to the 5,400-foot elevation would be backfilled with 33,300,000 cubic yards (50,000,000 tons) of waste rock material from the East Waste Rock Dump Complex. Cast blasting and dozing of the upper pit highwall would be used to create the 2H:1V slope on the highwall above 5,400 feet (Figure 2-4 cross section of pit). Cast blasting would enlarge the pit by 56 acres from 218 to 274 acres in order to achieve overall 2H:1V slopes and provide haul routes for pit backfilling and soil replacement (Figure 2-4).

No pit highwall would remain exposed under this alternative. Backfilling the pit under this alternative would eliminate pit highwall raveling and sloughing over time. Cast blasting would also enhance the inherent stability of the pit highwall by reducing the slope to 2H:1V from a current average of 0.8H:1V. Thus, the long-term stability of the pit highwall would be greater than the No Pit Pond Alternative. The agencies assumed in the No Pit Pond Alternative that the highwall would ravel and have occasional failures of up to 100,000 cubic yards over time. The agencies have assumed that disturbance caused by cast blasting under the Partial Pit Backfill With In-Pit Collection Alternative would be greater than the total acreage disturbed by highwall failures assumed under the No Pit Pond Alternative over time.

4.2.2.2.2 Pit Highwall Maintenance Requirements

The highwall would be covered by backfill, cast blasted highwall rock, and soil. Some physical and chemical weathering would occur over time in the highwall rock, especially in seep areas. No highwall maintenance would be needed under the Partial Pit Backfill With In-Pit Collection Alternative.

4.2.2.3 Backfill

4.2.2.3.1 Backfill Maintenance Requirements

As described in Section 4.2.1.5.2, geotechnical testing of the backfill and cast blasted materials showed that settlement would be expected during and after backfilling operations (Telesto, 2003e). The backfilled pit area would be subject to more settlement than a large portion of the waste rock dump complexes because of the thickness of the backfill. Settlement of waste rock used as backfill would be reduced because the waste rock has already weathered in the waste rock dump complex. Some backfilled areas in deep portions of the pit could still settle as much as 150 feet (Telesto, 2003d). Since the backfill material would be composed of mainly gravel and sand sized particles from the waste rock deposits and would be applied in an unsaturated condition, the agencies expect that 60 to 75 percent of settlement will occur during the backfilling process.

Although long-term settlement in the 775 to 875 feet of backfill would not affect pit highwall stability, it is likely that depressions would occur in the backfill material and the cast blasted material on the 2H:1V slopes due to the settlement of the backfill. These depressions would become locations for surface water accumulation and infiltration and could be sites where saturation and instability of the soil cover would be initiated. Monitoring would be needed to watch for settling of the cover. If ponding occurred, more soil would need to be replaced to restore the gradient. Settlement along a storm water diversion could result in erosion on the face of the revegetated slopes. To minimize this impact, monitoring of bench gradients and reestablishment of gradients would be needed over time. For maintenance of soiled and revegetated areas, see Section 4.2.1.7. For maintenance of storm water diversions, see Section 4.2.2.6.1.

If the Partial Pit Backfill With In-Pit Collection Alternative were selected, the agencies would consider requiring GSM to delay final reclamation of the backfill and cast blasted material until monitoring of the backfill indicated that most of the settlement had occurred. Even though 60 to 75 percent of the settling would have occurred, dewatering well failure would continue due to the remaining 25 to 40 percent settling as waste rock in the backfill weathered over time. Dewatering well failure and subsequent saturation of the backfill would lead to up to 31 percent additional settlement (Telesto, 2003d). In addition, problems of corrosion discussed in Section 4.2.2.5 would still be a problem.

4.2.2.4 Underground Workings

4.2.2.4.1 Impacts to Pit Facilities Due to Subsidence Related to Underground Mining

Impacts due to subsidence in the underground workings would be the same as under the No Pit Pond Alternative. The underground workings and portal monitoring and maintenance plan could not be implemented because access to the underground would be covered with up to 875 feet of backfill material.

Localized failures of overhead rock in the underground workings over time could result in subsidence, especially in seep and fault areas where chemical weathering would be increased. This subsidence could cause the backfill to further settle, potentially affecting the dewatering wells in the backfill. The agencies would require GSM to backfill the underground workings remaining after Stage 5B to minimize settlement. The agencies would require GSM to replace wells that failed.

4.2.2.5 Groundwater/Effluent Management System

4.2.2.5.1 Operation Requirements (Number of Wells)

The 1997 Draft EIS, Chapter II, Section II.B.7.b described a pit dewatering system for the Partial Backfill Alternative consisting of a series of wells drilled to depths below the 5,050-foot elevation. In this SEIS, the dewatering system for the Partial Pit Backfill With In-Pit Collection Alternative would consist of four wells from 775 to 875 feet deep to keep the groundwater level as close as possible to the 4,525-foot pit bottom elevation.

The wells would be drilled until they penetrate the bedrock under the backfill. As described in Section 2.4.3.3, boreholes would be 10 to 12 inches in diameter and would be lined with 6-inch-diameter stainless steel casing. The bottom 200 to 300 feet of the casing would be slotted. The water level would be maintained as low as possible in the backfill. A stainless steel submersible pump equipped with electronic sensors to maintain optimum drawdown would be installed in each well. The water would be routed by pipeline to the water treatment plant prior to being discharged back into the ground, away from the pit area, in percolation ponds, LAD areas, or other approved locations.

The dewatering wells would be subject to settlement and corrosion. Scaling and biofouling are not expected to be a problem because of the low pH of the pit water. The agencies would require GSM to replace wells that failed. The permeability of the backfill could change as described in Section 4.2.2.1.2.

4.2.2.5.2 Maintenance of Capture Points

Installation and long-term operation of dewatering wells in backfill under this alternative would be similar to the No Pit Pond Alternative but more problematic. The main differences are:

- Drilling and completing wells through an additional 675 to 775 feet of unconsolidated backfill;
- Effectiveness of pumping from wells in an additional 675 to 775 feet of heterogeneous backfill, some of which would be fine-grained and of lower permeability;
- Maintaining the water table as low as possible at lower pumping rates and higher lifts (HCI, 2002);
- Maintaining pump intake openings, slotted casings, and sensors that would be subject to corrosion; and,
- Maintaining structural integrity of dewatering wells due to long-term settlement of the additional 675 to 775 feet of backfill.

Drilling to depths greater than 100 feet within acidic waste rock backfill presents unique problems and challenges. Problematic issues when drilling in poorly consolidated or unconsolidated materials such as backfill include: poor circulation, low recovery, reduced drilling rates, and decreased borehole stability. Telesto recently completed a drilling program in southern Arizona in a blasted, unconsolidated, brecciated formation similar to conditions that would occur in pit backfill at GSM (J. Finley, Telesto, personal communication, 2003). During the drilling program, circulation was lost approximately 60 feet below ground surface and all attempts to regain circulation were unsuccessful. In the course of drilling a 400-foot boring, over 1,000 bags of bentonite were added to the drilling fluid in an unsuccessful attempt to regain circulation. Enough chip-seal (cedar fibers and cottonhulls) was used to completely clog the recirculation system on the drilling rig with no effect on recovery of drilling solution or underground geologic material. Drilling rates averaged approximately 1.5 feet per hour because of the difficulty in drilling through the rubble material and the time required to mix the large quantities of drilling mud. The potential for the bore hole to collapse required drilling with very frequent casing advancement (casing was advanced approximately every 5 to 10 feet) further slowing the drilling rates. Borehole stability was enough of a concern that drilling the rubble material required around-the-clock drilling operations so that borehole collapse would be minimized. Drilling in the breccia formation required approximately three times the amount of hours anticipated by both experienced geologists and drillers, and approximately 15 times longer than drilling in natural, unconsolidated formations. Drilling through unconsolidated breccia material is not impossible, but difficult and expensive. Installing wells at depths greater than 400 feet would be more difficult.

A screening level feasibility assessment of pumping from a backfilled pit was performed for this SEIS (Telesto, 2003e). The Partial Pit Backfill With In-Pit Collection Alternative was evaluated for its functionality, conformance to industry standards, and construction feasibility. Permeability of the backfill is the principal property determining the effectiveness of dewatering wells. If permeability is too low, groundwater would not move into a well fast enough or from a sufficient region to allow the pump to function properly (HCI, 2002).

All available permeability values for waste rock samples from GSM, consisting of 23 tests (5 laboratory and 18 field tests), were summarized (Telesto, 2003d). The geometric mean of these data was approximately 1×10^{-3} cm/sec. The 90th percentile value was approximately 1×10^{-4} cm/sec. All samples were from the upper 15 feet of the waste rock dump. Telesto concluded that after backfilling, the permeability could be expected to range from 1×10^{-3} to 1×10^{-5} cm/sec. Based on this analysis, it was concluded by GSM's consultant that initially the permeability of the backfill would be adequate for dewatering under this alternative. The agencies believe that the permeability would decrease over time under 875 feet of backfill with variable or incomplete drainage. In addition, cementing of the backfill by oxidation byproducts in the water could eventually create some perched water tables or areas of limited permeability around the wells.

The agencies do not believe that the standard permeability analyses as completed by Telesto (2003d) using homogeneous modeling of waste rock are representative of the long-term permeability of the waste rock in the backfilled pit. The 100 feet of crusher reject would be permeable at first but would weather and break down over time. This would limit the ability to pump out water effectively. In addition, the acidic water and waste rock is full of microbes, which accelerate the ARD reaction and could increase potential biofouling, depending on the pH of the water. Acidic water increases corrosion. Scaling, from iron hydroxide formation, and biofouling would not reduce permeability over time because of the low pH of the pit water.

It is questionable that the water level can be maintained at the 4,525-foot elevation and pumped up to 875 feet out of a 6-inch stainless steel casing continually with only a 15 gpm flow. Water level would probably have to rebound up in the slotted casing and then be pumped intermittently to effectively pump from that depth. This would increase the production and flushing of oxidation products as the water level fluctuates in the backfill and not meet the agencies' goal of maintaining the water level as low as possible in the backfill.

Based on backfill settlement discussed in Section 4.2.3.3, up to 150 feet of settlement could occur over the deepest part of the pit over several years (Telesto, 2003e). If the water table rebounded because dewatering wells could not effectively pump from 775 to 875 feet deep, this would cause up to an additional 31 percent settlement in the saturated portion of the backfill.

Corrosion, scaling, and potential biofouling were addressed in the No Pit Pond Alternative Section 4.2.1.5.2. The corrosive nature of the backfill groundwater, along with the settlement of the backfill, could create difficulties in the implementation of the

Partial Pit Backfill With In-Pit Collection Alternative. The following measures may lessen the impacts due to settling and corrosion but not eliminate them:

- Allow time for settlement, which could result in 10 percent of the ARD leaving the pit along faults and other flow paths if the water level rose to the 5,050-foot elevation;
- Wait until backfill saturation approaches the design elevation of the dewatering well screens, which would increase the flushing of oxidation byproducts and allow more settlement to occur in the saturated backfill;
- Install additional dewatering wells in case of failure due to settlement and corrosion; and,
- Install shallower wells as an alternate water level control, which would increase the amount of water escaping the pit, flushing of oxidation byproducts, and settlement.

The agencies considered the risks and uncertainties of all these measures. Settlement is the highest risk. Some measures would increase the potential for creating more acidic water, which would move out of the pit and have to be captured down gradient. These measures do nothing to reduce corrosion, which is a risk to well failure. These measures do nothing to improve the ability to drill 875-foot wells in unconsolidated waste rock backfill.

If pumping can’t maintain the water level at the 4,525-foot elevation, groundwater within the pit backfill would become more acidic and metal laden than current pit water. Due to the 775 to 875 feet of backfill and the need for deep wells, control of the groundwater level would be more difficult under the Partial Pit Backfill With In-Pit Collection Alternative than the No Pit Pond Alternative.

As described in Section 4.2.2.3, 150 feet of settling of the 775 to 875 feet of backfill would occur over time. This settling could affect the integrity of the well casings causing casings to separate in the compacting and consolidating material. Settling could also affect pumps, electrical components, monitoring equipment and pipelines requiring periodic repair and replacement. Additional settling could occur if the backfill becomes inundated. Most settlement would occur within the first few years of placement, but 25 to 40 percent would occur over a longer period, after wells would likely be installed, subjecting them to stresses sufficient to buckle or shear the casings requiring complete replacement of wells over time. This could lead to elevated groundwater levels in the backfill, increasing ARD migration out of the pit if the water table rose above the 5,050-foot elevation (Telesto, 2003a).

The number of wells required would be more than the No Pit Pond Alternative to provide adequate capacity to create an effective cone of depression in the 775 to 875 feet of acidic backfill. The corrosive nature of the pit backfill groundwater and potential damage to the well casings from settling backfill indicate that redundancy would also be necessary to maintain effective dewatering. Because of the risks and uncertainties, GSM would be required to replace wells that failed.

As described in Section 4.2.1.5.2, corrosion of the screens and pumps, well casings, electrical components, monitoring equipment and pipelines from the acidic crusher reject and acidic water in the backfill would cause periodic need for repair and replacement of dewatering system components.

Other problems with maintenance include trying to maintain pumps at low pumping rates and high lifts and replacing wells and pumps over time. These are more problematic than the No Pit Pond Alternative, which would require less lift and higher pumping rates in the 100 feet of backfill. The only capture points would be the four dewatering wells. The underground sump could not be used as a contingency in this alternative because the underground workings would be buried under more than 500 feet of backfill.

4.2.2.6 Storm Water Runon/Runoff Management

4.2.2.6.1 Maintenance Requirements

Maintenance requirements for storm water diversions under this alternative would be the same as under the No Pit Pond Alternative.

The storm water runon/runoff system to keep surface water out of the pit under the Partial Pit Backfill With In-Pit Collection Alternative would be similar to the No Pit Pond Alternative except the location would be different due to the 56 acres of new disturbance created by cast blasting. More than 99 percent of the storm water would be diverted away from the pit (Telesto, 2003a).

Benches would be created on the 2H:1V slopes every 200 vertical feet. Storm water diversions would be constructed on the benches and graded to route water out of the pit area. The backfilled surface of the pit would be graded at 4.3 percent to drain surface water out the eastern rim of the pit at the 5,350-foot elevation.

On the 2H:1V slopes, dozer basins would be created as on the waste rock dump complexes to control erosion until vegetation becomes established. Rocky soils containing up to 45 percent coarse fragments would help to limit erosion and sedimentation in storm water diversions.

The agencies have assumed 0.5 to 1.1 inches of precipitation would infiltrate into the pit backfill as on waste rock dump slopes (HSI, 2003). This is included in the 15 gpm of pit seepage that would be collected and treated (Telesto, 2003a).

The risks and uncertainties for storm water diversions outside of the pit would be the same as under the No Pit Pond Alternative. Settlement in the backfill as described in Section 4.2.2.5.2 could cause depressions, which would become locations for surface water accumulation and infiltration and could be sites where saturation and instability of the soil cover would be initiated. Settlement along a storm water diversion could result in erosion on the face of the reclaimed slopes. To minimize this impact, monitoring of bench gradients and reestablishment of gradients would be needed over time.

4.2.2.7 Soil Cover

4.2.2.7.1 Soil Cover Maintenance Requirements

As described in Section 2.4.3.6, GSM has proposed a 3-foot soil cover on 274 acres to be revegetated in the pit area. Monitoring of backfill settlement would be the same as described in the No Pit Pond Alternative, Section 4.2.1.7, but there would be more settlement because of the depth of the backfill. There would be no raveling and sloughing affecting the cover. Any acreage revegetated in the pit would need to be monitored for erosion and noxious weeds. Eroded areas would need to be repaired, resoiled and reseeded. Noxious weeds would have to be controlled.

As described in Section 4.2.3.3, some grading and/or dozing of the backfill surface would be needed as the backfill settles. This would affect the soil cover and more soil would have to be placed and reseeded.

GSM has constructed soil covers on waste rock dump complexes and tailings impoundments over the past 10 years. On waste rock dump complexes, the dump material and covers have not become saturated, and settlement or erosion problems have been limited. GSM monitors storm water diversions on waste rock dumps. If settling occurs, the gradient would be re-established as necessary. On Tailings Impoundment No. 1, where the tailings were saturated and are dewatering over time, settlement has resulted in the necessity for maintenance activities (GSM, 2002c). GSM monitors settlement and soil is replaced as needed to prevent ponding on the impoundment surface and to provide drainage off the impoundment surface.

After cast blasting and dozing the pit highwall to a 2H:1V slope, a 3-foot soil cover with 45 percent rock fragments would be placed over the waste rock and revegetated. The soil cover was analyzed for stability (Telesto, 2003d). Analyses showed that small localized stability problems would exist for the soil cover if the soil became saturated, especially if the backfill was relatively impermeable in localized areas. Small localized failures could develop because highwall seeps could flow laterally through and saturate the cover. Seep water would be acidic and would contaminate soils and impair revegetation success if allowed to contact the soil cover. To improve soil cover stability in these localized areas after a failure, the seep would be located and dewatered, contaminated soil would be replaced with clean soil, and the area would be revegetated. In highly permeable areas, such as the Corridor Fault, seep areas would be more common.

Steam vent monitoring under the current permit would be modified to include the pit area as well as the waste rock dumps.

4.2.2.8 Water Treatment

The water treatment plan under the Partial Pit Backfill With In-Pit Collection Alternative would be the same as the No Pit Pond Alternative. In the 1997 Draft EIS, Chapter IV, Section IV.B.7.b, the agencies predicted that up to 50 gpm of pit water would be treated under the Partial Backfill Alternative. Because only an estimated 15 gpm of pit water would be treated under the Partial Pit Backfill With In-Pit Collection Alternative as a result of the new water balance completed for this SEIS (Telesto, 2003a), no change in treatment or disposal methods would be needed.

No other pit discharge was assumed in the 1997 Draft EIS for the Partial Backfill Alternative. The water treatment plant approved in the 1998 ROD had a total design capacity of 392 gpm. No changes in treatment plant design capacity would be needed for the Partial Pit Backfill With In-Pit Collection Alternative.

4.2.2.8.1 Additional Sludge Management Requirements

The quality of the water assumed to be treated in the 1997 Draft EIS was not as poor as the water quality projections of pit water to be treated used in this SEIS (see Table 4-5 in Section 4.3.3.1). In addition, the weathering processes observed in the waste rock dump complexes would continue to produce oxidation byproducts in the unsaturated portion of the backfill. Jarosite in the saturated portion of the backfill would prevent reducing conditions from developing, as can sometimes occur within submerged materials because of the lack of oxygen (see Section 4.3.3.1.1.2.1). Jarosite would allow further production of acid. Jarosite is soluble under the foreseeable conditions and would be expected to dissolve slowly adding dissolved ferric iron to the water. Pumping of pit water to maintain the water level at the 4,525-foot elevation would limit saturation of the backfill and impacts from jarosite dissolution.

More sludge would be produced per gallon of treated water compared to the No Pit Pond Alternative, but the volume of water to be treated would be about one-third, so the sludge management requirements would be similar to or less than that analyzed in the 1997 Draft EIS.

4.2.2.8.2 Additional Operating Requirements

The water treatment system in this SEIS is the same as that evaluated in the 1997 Draft EIS. There would be less water to treat from the pit, so there would be no additional operating requirements at the water treatment plant.

The four dewatering wells in this alternative are located at the 5,400-foot elevation. If the water could be pumped out of the wells regularly without failure of the pumps due to corrosion, routing water from the 5,400-foot elevation would be easier than from the 4,625-foot elevation under the No Pit Pond Alternative.

If the drought has affected the seepage predictions on this SEIS and more water would need to be treated than expected, the existing permit stipulation based on Measure W-6 approved in the 1998 ROD as Stipulation 010-9 would be adequate.

4.2.2.9 Flexibility for Future Improvements

4.2.2.9.1 Potential for Utilization of New Technologies

It is estimated that 15 gpm of water from the pit would need to be treated under the Partial Pit Backfill With In-Pit Collection Alternative.

The water would need to be pumped out of 775 to 875 feet of acidic backfill. This can be done although it would be more difficult in the weathering, unconsolidated, acidic waste rock. The acidic water would require regular maintenance and replacement of pumps and other dewatering system components. The agencies believe that, because of the problems with maintaining wells in acidic waste rock, the partial pit backfill alternatives offer less potential for utilization of new technologies because of the deeper backfill.

The Partial Pit Backfill With In-Pit Collection Alternative would be less able to accommodate future technological improvements in controlling water quality and quantity than the No Pit Pond Alternative. It would be easier to redesign the system in 100 feet of backfill than in 775 to 875 feet of backfill. It would be easier to remove 111,000 cubic yards (167,000 tons) than 33,300,000 cubic yards (50,000,000 tons) of backfill and 11,900,000 cubic yards (17,900,000 tons) of cast blasted highwall rock.

As discussed in the No Pit Pond Alternative, research is being conducted on treating pit water with chemicals, carbon sources, microbes, etc. in various locations around the world. If an alternative to pumping and treating were developed in the future, it would be easier to treat pit water in an open body of water than in backfill.

If pit water had to be treated in backfill, it would be easier to treat it in the 111,000 cubic yards (167,000 tons) of waste rock in the pit under the No Pit Pond Alternative than it would be in the 33,300,000 cubic yards (50,000,000 tons) of waste rock placed in the pit under the partial pit backfill alternatives.

Pit water balance studies completed for this SEIS concluded that for the Pit Pond Alternative, dismissed in Section 2.5.4, the water level would rise and stabilize at the 4,635-foot elevation due to evaporation of water from the highwall and pit pond. The agencies believe that the15 gpm of pit inflow would not leave the pit. If the dewatering system failed under the Partial Pit Backfill With In-Pit Collection Alternative with the volume of backfill placed in the pit, the water would eventually begin discharging at the 5,050-foot elevation. It would be easier to implement treatment systems using chemicals, carbon sources, microbes, etc. in an open body of water than in a pit backfilled with waste rock.

4.2.2.9.2 Consequence of Failure

If implementation of the alternative failed for any reason, the water level would rise in the backfill, above the 5,050-foot elevation and reach a steady state at the 5,260-foot elevation. An estimated 16 gpm would leave the pit and would have to be captured down gradient as under the Partial Pit Backfill With Downgradient Collection Alternative. Other treatment technologies implemented in the pit would be limited. If downgradient collection was not installed, eventually groundwater quality standards would be exceeded at the mixing zone boundary from the 16 gpm pit discharge (Telesto, 2003e).

4.2.3 Partial Pit Backfill With Downgradient Collection Alternative

4.2.3.1 Design and Constructibility of the Alternative

4.2.3.1.1 Proven Design

Backfilling and cast blasting under the Partial Pit Backfill With Downgradient Collection Alternative would be the same as for the Partial Pit Backfill With In-Pit Collection Alternative.

The dewatering system design would be more complex, requiring at least 26 dewatering wells,10 monitoring wells, and 2 acres of new road and pipeline and powerline disturbance, but is a proven design. Pumping out of drainages from wells up to 200 feet deep in various geologic formations is done regularly. The water quality down gradient would not cause as much failure of dewatering system components due to corrosion from acidic water as pumping from backfill in the pit under the No Pit Pond and Partial Pit Backfill With In-Pit Collection alternatives. Scaling from iron hydroxide formation and potential biofouling could increase because of the higher pH of the captured water. Limited scaling has occurred at GSM (Section 4.2.1.5.2.1.5).

4.2.3.1.2 Ability to Construct the Alternative at GSM

The volume and depth of backfill and cast blasted material would be the same for both partial pit backfill alternatives.

No wells would be constructed in the up to 875 feet of backfill under this alternative. At least 26 dewatering wells and 10 monitoring wells would be constructed down gradient of the pit in Rattlesnake Gulch and along geologic structures around the pit (Figure 2-7).

Installing dewatering wells at GSM in similar geologic materials has been done successfully. Based on GSM's experience in drilling monitoring and pumpback wells, the agencies believe that only a maximum of 80 percent of the 16 gpm of pit discharge would likely be captured in these wells because of uncertainty about flow paths. More wells would probably be needed to attempt capturing a sufficient percentage of the pit discharge. The Tailings Impoundment No. 1 south pumpback system (Figure 3-5) would have to be maintained as well. An overall 95 percent capture efficiency would need to be achieved across the two pumpback systems to prevent water quality violations at the mixing zone boundary. Ninety-five percent capture efficiency may not be achievable based on GSM's experience capturing Tailings Impoundment No. 1 seepage.

GSM has been capturing Tailings Impoundment No. 1 seepage since the 1983 leak of tailings solution through the improperly constructed bentonite slurry cutoff wall. Chronologies of events about the leak and capture systems from 1983 through 2003 have been compiled (GSM 1991 annual report: Table 1; Spectrum Engineering, 2004: Appendix A).

Four pumpback wells were constructed in 1983. In 1986,15 pumpback wells were in place. In 1991, 22 more pumpback wells were constructed. As detailed in various annual reports, new monitoring wells and pumpback wells have been constructed and old wells have had to be decommissioned or replaced regularly. Wells were refurbished in 1995 and 2001. In 2004, 16 pumpback wells are still being pumped, and a total of 55 monitoring wells are being sampled to track the leakage from Tailings Impoundment No. 1 (Portage Environmental, 2004).

Various reports have been prepared since 1980 about the impoundment, documenting the problem and addressing agencies' comments about GSM's ability to contain the seepage (SHB, 1980, 1982, 1983, 1985, 1986, 1987, and 1989b; DSL, 1987 and 1988; Hydrometrics, 1991, 1994, 1997; Keats, 2001; HydroSolutions, 2003; Spectrum Engineering, 2004; Portage Environmental, 2004). Despite continual upgrading of the wells, some seepage is escaping the south pumpback system. Data suggest slow migration of seepage away from Tailings Impoundment No. 1 (GSM 1998, 1999, and 2000 annual reports). There also is a vertical component to the seepage migration as well (GSM 2000 annual report).

Keats (2001) concluded the second and third rows of pumpback wells were not completely capturing the seepage. Keats recommended treatment at the source area rather than adding pumpback wells. This was due in part to the difficulty in defining smaller scale contaminant pathways. GSM has been testing in situ injection in the area with DEQ and EPA approval to achieve treatment at the source since the Keats report was completed.

Portage Environmental Inc. reviewed the current monitoring well program in 2004. It summarized the level of contamination in all wells in the report. The majority of wells below the pumpback system still show some cyanide, nitrate, or metal contamination. It is hard to define how much of that is from the 1983 leak or from the continued migration of seepage past the capture systems. The agencies and GSM continue to review sampling results and modify the seepage containment system to prevent violations at the permit boundary.

A new well was constructed in 2004 to identify sources of nitrate that may or may not be related to the mine (Spectrum Engineering, 2004). Another new well drilling program was approved in October 2004 to identify the nitrate source(s) in the area wells. Each new well placed in the Bozeman Group shows variable geology and the discontinuity of lithologic units within the Group.

The Bozeman Group is a variable aquifer and has been the subject of many studies since 1980. GSM is capturing the majority of the seepage from Tailings Impoundment No. 1, but the process is complex and a large number of pumpback and monitoring wells have been developed and still are needed. Some seepage continues to escape the pumpback system. Efforts continue to ensure that violations do not occur at the mixing zone boundary.

For this SEIS, modeling indicated that an overall 95 percent capture efficiency would be needed to prevent violation at the mixing zone boundary. GSM's experience since 1983 trying to capture Tailings Impoundment No. 1 seepage indicates this goal may not be achievable.

DEQ has been addressing concerns with capture system efficiency at other sites, including Zortman/Landusky, CR Kendall, Black Pine, and PPL Montana in Colstrip. At Colstrip, PPL Montana continues to have problems containing seepage through a variable Tertiary aquifer. None of these systems capture all seepage.

Containing groundwater in the pit offers a greater degree of control of contaminants than trying to capture contaminants in a variable aquifer closer to the mixing zone boundary. Treatment at the source (i.e., pumping directly from the pit sump) in the No Pit Pond or Underground Sump alternatives is easier to achieve than treating by collection and pumping from downgradient wells. Adding more water to the Rattlesnake Gulch flowpath may accelerate and complicate existing capture system collection efforts.

4.2.3.2 Pit Highwall

4.2.3.2.1 Pit Highwall Stability

Pit highwall stability under this alternative would be similar to the Partial Pit Backfill With In-Pit Collection Alternative.

Stability of the pit highwall would not be affected by the water table rebounding and stabilizing at the 5,260-foot elevation (Telesto, 2003d).

4.2.3.2.2 Pit Highwall Maintenance Requirements

Pit highwall maintenance requirements would be similar to the Partial Pit Backfill With In-Pit Collection Alternative.

Highwall maintenance would be similar to the Partial Pit Backfill With In-Pit Collection Alternative.

4.2.3.3 Backfill

4.2.3.3.1 Backfill Maintenance Requirements

Backfill maintenance requirements would be the same for the No Pit Pond and pit backfill alternatives. Under this alternative, the backfill would become saturated to the 5,260 foot elevation as the water table rebounded.

As described in Section 4.2.2.5.2, up to 150 feet of settlement would occur over time. Sixty to 75 percent would occur during backfilling. The rest would occur over the long term (Telesto, 2003d). The settlement tests performed on the waste rock specimens were analyzed in a dry condition to mimic end dumping that would occur during backfilling. Following the settlement tests, the specimens were inundated with water to simulate water filling of the pit. This inundation by water added an additional 31 percent average settlement (Telesto, 2003d).

Settlement could extend below the toe of the steep 2H:1V slopes causing the slope to slough. If the function of the storm water diversions on the benches is affected, gullies would form. One way to mitigate this adverse impact would be to delay installing the drainage controls and soil cover until the backfill has sufficiently stabilized, as described in Section 4.2.2.5.2. According to the consolidation tests conducted using the backfill material, settlement would stop once the backfilled pit has been fully inundated. After inundation of the pit, the settlement could be as much as 167 to 200 feet. During this delay, downgradient dewatering would have to continue. It would take nearly 100 years for inundation of the pit backfill to occur.

The maintenance requirements would be more than for the Partial Pit Backfill With In-Pit Collection Alternative due to additional 31 percent settling from inundation of the backfill to the 5,260-foot elevation.

4.2.3.4 Underground Workings

4.2.3.4.1 Impacts to Pit Facilities Due to Subsidence Related to Underground Mining

Impacts due to subsidence in the underground workings under this alternative would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative.

The risks and uncertainties would be similar to the Partial Pit Backfill With In-Pit Collection Alternative.

4.2.3.5 Groundwater/Effluent Management System

The water balance for this SEIS concluded that for the Partial Pit Backfill With Downgradient Collection Alternative, an estimated 16 gpm would discharge from the backfilled pit. The primary objective of the Partial Pit Backfill With Downgradient Collection Alternative would be to try to avoid pit dewatering completely by letting the pit water table rebound in the backfill and letting the pit effluent discharge into the regional groundwater system. The pit discharge would move down primary and secondary groundwater flow paths, partially attenuate, and mix with ambient groundwater. A maximum of 121 gpm of ambient groundwater, East Waste Rock Dump Complex seepage, and pit discharge would be collected in Rattlesnake Gulch using the existing

Rattlesnake Gulch dewatering wells and the Tailings Impoundment No. 1 capture system supplemented with additional wells as described in Section 2.4.4.3.

4.2.3.5.1 Operation Requirements (Number of Wells)

As described in Section 2.4.4.3, at least an additional 26 capture wells and 10 monitoring wells would be needed to monitor and capture the Rattlesnake Gulch water. Ninety-five percent of the 16 gpm would need to be captured to prevent impacts to groundwater at the mixing zone boundary (Telesto, 2003e). More wells may be needed as described in Section 4.2.3.1.2. An overall 95 percent capture efficiency may not be achievable based on GSM's experience with Tailings Impoundment No. 1 seepage, as described in Section 4.2.3.1.2.

As described in Section 4.3.4.1.2.2.1, as a result of trying to capture an overall 95 percent of the 16 gpm of pit seepage, an approximate 53 to 104 gpm of additional ambient groundwater would be collected in the process. The number of wells and the need to collect additional water reflect the uncertainties of effective contaminant collection in an alluvial aquifer and collection of contaminants in the fractured bedrock aquifer.

4.2.3.5.2 Maintenance of Capture Points

Maintenance of downgradient collection wells would be less problematic than those in acidic backfill. As described above, capturing groundwater at distances down gradient of the pit introduces uncertainty as to the effectiveness of capture of all contaminated groundwater in the heterogeneous Bozeman Group and in fracture flow systems. It also necessitates the collection of a greater volume of groundwater.

The collection wells would need to be monitored and maintained regularly to ensure pumping efficiency. Additional operator time would be needed to access the wells around the pit. The powerlines, pipelines and access roads would also need to be maintained. The well casings in natural geologic formations would not be subject to the settling effects of the backfill. In addition, the pumped water quality could be better for a few years due to short-term buffering by the aquifer and mixing with ambient groundwater, which would limit corrosion and extend pump life. Once the attenuation and buffering capacity of the aquifer is used up (projected to be a few tens of years (HSI, 2003)), then water quality would be similar to the pit water quality. GSM has been maintaining capture wells below the impoundments for many years (Section 4.2.1.5.2.1.5) and the costs of this maintenance are well documented. Bond would be calculated to cover the additional costs of maintaining the complex collection system. An overall 95 percent of the 16 gpm of pit seepage would need to be captured. A maximum of 121 gpm of ambient groundwater, East Waste Rock Dump Complex seepage, and pit discharge would have to be collected in the process. Ninety-five percent capture may not be achievable, as described in Section 4.2.3.1.2.

4.2.3.6 Storm Water Runon/Runoff Management

4.2.3.6.1 Maintenance Requirements

The storm water runon/runoff management maintenance requirements for this alternative would be the same as the Partial Pit Backfill With In-Pit Collection Alternative.

The storm water runon/runoff management maintenance risks and uncertainties for this alternative would be the same as the Partial Pit Backfill With In-Pit Collection Alternative.

4.2.3.7 Soil Cover

4.2.3.7.1 Soil Cover Maintenance Requirements

The soil cover maintenance requirements for this alternative would be the same as the Partial Pit Backfill With In-Pit Collection Alternative.

Risks and uncertainties with soil cover maintenance would be the same as the Partial Pit Backfill With In-Pit Collection Alternative.

4.2.3.8 Water Treatment

The water treatment plan under the Partial Pit Backfill With Downgradient Collection Alternative would be the same as all other alternatives. In the water balance study completed for this SEIS, it was estimated that 16 gpm would discharge from the pit and be collected in the existing pumpback collection systems and at least an additional 26 downgradient wells. The agencies have assumed that a maximum of 121 gpm would be collected and treated as a result of trying to capture the 95 percent of the 16 gpm discharge needed to prevent water quality impacts at the mixing zone boundary. In the 1998 ROD, the agencies predicted treatment of 102 gpm of pit water under the No Pit Pond Alternative. The present treatment plant design capacity would be adequate (Table 4-2). The additional water would not require a change in treatment or disposal methods. The quality of the water from the saturated pit would be worse because of the geochemical processes associated with weathered acidic, metal laden waste rock backfill of the pit under both saturated and unsaturated conditions.

4.2.3.8.1 Additional Sludge Management Requirements

As mentioned above, with downgradient collection, a maximum of 121 gpm would be collected and treated along with 95 percent of the pit discharge under this alternative to prevent impacts at the mixing zone boundary.

The quality of the water in the backfill would be the same as in the Partial Pit Backfill With In-Pit Collection Alternative. Jarosite in the saturated portion of the backfill would prevent reducing conditions from developing, as can sometimes occur within submerged materials because of the lack of oxygen. Jarosite would allow further production of acid. Metals release would occur during the dissolution of jarosite because ferrous iron usually predominates below the water table. The flow from the unsaturated portion of the backfill above the water table would continue to contribute low pH water with high metals concentrations to the pit discharge for hundreds of years. The rock along the primary and secondary flow paths from the pit has limited natural attenuation capacity, or ability to reduce the metals concentration or increase pH of the groundwater flow (HSI, 2003; Telesto, 2003e). The sludge management requirements would be roughly the same between alternatives with and without pumping because the chemical mass produced is roughly the same (Robertson GeoConsultants, 2003).

4.2.3.8.2 Additional Operating Requirements

Under the Partial Pit Backfill With Downgradient Collection Alternative, 26 more collection wells and 10 more monitoring wells would be needed in the dewatering system than with the Partial Pit Backfill With In-Pit Collection Alternative. This would require more spur pipelines and powerlines to the main pipeline and powerline to transport the captured water to the treatment plant. The agencies have assumed an additional 2 acres would be disturbed for new roads, pipelines, and powerlines to the wells.

The extra wells, pipelines, powerlines and roads would require more monitoring time than the other dewatering systems. The collection and monitoring wells under this alternative would not be subject to other problems that the wells in the acidic backfill would be subject to such as settling damage to casings and corrosion. The collection and monitoring wells could be subject to limited problems with corrosion, scaling, and potential biofouling of pumps and screens, etc., due to increased pH of the captured water. The wells would also not be as deep and therefore would not have the problems with high lift out of the deep backfill. The water treatment plant could require additional operating cost due to the increased water quantity (121 gpm) that would be collected in the downgradient capture wells, as compared to the other alternatives. The 349 gpm volume from all sources needing treatment under this alternative would still be less than the 392 gpm water treatment plant capacity approved in the 1998 ROD.

4.2.3.9 Flexibility for Future Improvements

4.2.3.9.1 Potential for Utilization of New Technologies

The potential for utilization of new technologies under this alternative would be similar to the Partial Pit Backfill With In-Pit Collection Alternative except that future backfill water treatment methods that require injection of chemicals, carbon sources, microbes, etc. would be more difficult because of the lack of wells in the backfill. Wells could be installed. If treatment were attempted outside of the pit, a dispersed plume may be more challenging to track and contain.

4.2.3.9.2 Consequence of Failure

If implementation of the alternative failed for any reason, modeling shows that groundwater quality standards would be exceeded at the mixing zone boundary. Failed wells would be repaired or replaced and additional wells could be drilled.

4.2.4 Underground Sump Alternative

4.2.4.1 Design and Constructibility of the Alternative

4.2.4.1.1 Proven Design

The pit would not be backfilled under this alternative. Waste rock containing sulfides would remain stored and capped above the water table in the East Waste Rock Dump Complex. Dewatering would occur in an underground sump. This is currently being done at GSM and at other operating and inactive mines. The Colorado Division of Minerals and Geology (CDMG), the Nevada Department of Natural Resources and Conservation (NDNRC), and the Nevada Department of Environmental Protection (NDEP) were contacted regarding this question (K. Gallagher, GSM consultant, personal communication, 2003). The NDNRC and NDEP could not provide specific methods of dewatering for each mine site, merely stating that the majority of mines in Nevada were dewatered. Mines listed by NDEP included Pipeline (Placer Dome America), Gold Quarry (Newmont), Meikle (Barrick Gold Strike), and Robinson (Quadra). Underground operations listed as being dewatered from a sump included Leeville (Newmont), Hollister (Hecla), and Getchell (Placer Dome America). The CDMG data are presented below in Table 4-3.

Table 4 - 3 Examples of mines being dewatered and their dewatering methods

Mine	Limited Backfill	Underground Sumps	Pit Ponds
Berkeley Pit – Butte, MT		From the 1960s to 1982, Anaconda Company dewatered Berkeley Pit from Kelley Shaft at 4,000-5,000 gpm (Canonie, 1994).	Montana Resources has pumped from the pit lake for process water.
Mayflower Mine Montana		In 1997 dewatered from sump at 1582 feet, pump @ 1200 level	
Battle Mtn – San Luis Colorado	Controlled dewatering/rinse of pit backfill for indefinite time. Treated and released.		
Homestake-Bulldog Colorado		Dewatered below lowest adit level to develop sub-adit level. Treated and released.	
Cotter Corp – Schwartzwalder Colorado		Dewatered below adit level (formerly) to develop sub-adit workings. Treated and released.	

Climax Molyb. Co – Climax Colorado		Perpetual pumping from main shaft to prevent overflow of groundwater out shaft. Treated and released.	
Gilt Edge South Dakota			Treated in the pond, pumped from the pond, and discharged

During stripping of waste rock for Stage 5B, GSM plans to dewater the mine from an underground sump. Water is drained to the sump through two drill holes from the 4,650-foot elevation. At closure, GSM would have to drill holes from the 4,525-foot elevation to an underground sump to drain water that would collect in the pit bottom.

It is technically feasible to install pumps in the underground workings at closure. During a portion of the underground operation, GSM dewatered the pit and underground working from a sump in the underground, as described in Section 4.2.1.5.2.1.4. Maintaining hydrologic connection between the pit bottom and the underground for dewatering has been successful. Periodic maintenance would be needed to ensure access to the 4,550-foot-elevation portal, to maintain the underground workings, and access to the sump. Pumps would need to be replaced as in other alternatives. Pipelines and powerlines may be damaged periodically by rock falls in the underground workings or from the highwall.

4.2.4.1.2 Ability to Construct the Alternative at GSM

No backfill would be placed in the pit under this alternative. The only work needed to construct this alternative would be to redesign the current underground dewatering system and develop the 4,550-foot elevation portal for future access.

The agencies would require GSM to submit a plan for development, maintenance and monitoring of a portal at a suitable elevation to maintain secondary access for dewatering. This would provide long-term access to the dewatering system for repair and maintenance and to provide safety for underground workers.

4.2.4.2 Pit Highwall

4.2.4.2.1 Pit Highwall Stability

Pit highwall stability under this alternative would be essentially similar to the No Pit Pond Alternative.

Under the Underground Sump Alternative, no waste rock or other material would be backfilled in the bottom portion of the pit. Dewatering of the pit would occur from within the existing underground workings. As the groundwater level in the pit highwall is drawn down during mining and maintained following mining, the pit highwall would remain stable. The portal at the 4,550-foot elevation could be destroyed by the failures assumed by the agencies under the No Pit Pond Alternative. The agencies would require GSM to submit a plan for development, maintenance, and monitoring of a portal at a suitable elevation to allow secondary access, dewatering in the future, and to protect workers in the pit and underground.

4.2.4.2.2 Pit Highwall Maintenance Requirements

Pit highwall maintenance requirements under this alternative would be similar to the No Pit Pond Alternative.

Depending on the location and nature of highwall raveling and sloughing over time, there is a possibility that access to the 4,550-foot portal and the underground dewatering system could be lost. If this were to occur, portions of the piping and power lines could be lost. The water table would begin to rebound in the underground workings. GSM would have to reestablish the 5,700-foot safety bench and access to the 4,550-foot portal, if possible, and repair any damaged dewatering components. The agencies would require GSM to submit a plan for development, maintenance and monitoring of a portal at a suitable elevation to maintain secondary access for dewatering. There would be no impacts outside of the pit.

4.2.4.3 Backfill

4.2.4.3.1 Backfill Maintenance Requirements

Not applicable to the Underground Sump Alternative.

4.2.4.4 Underground Workings

4.2.4.4.1 Impacts to Pit Facilities Due to Subsidence Related to Underground Mining

Impacts due to subsidence under this alternative would be similar to the No Pit Pond Alternative except localized failures of overhead rock in seep and fault areas could occur over time affecting access to the dewatering system in the underground workings. A monitoring and maintenance plan would be needed to ensure continued access to repair the dewatering system and to ensure worker safety. The monitoring and maintenance plan would be applied to both the 4,550 and contingency portal locations.

4.2.4.5 Groundwater/Effluent Management System

The principal objective of the Underground Sump Alternative would be to maintain the pit as a hydrologic sink, keeping the groundwater level below the final pit bottom at the 4,525-foot elevation.

4.2.4.5.1 Operation Requirements (Number of Wells)

There would be no new wells constructed under this alternative. Some drill holes would be needed to direct pit water to the underground sump. Construction of the underground dewatering system would be completed during the last phase of Stage 5B mining operations. The dewatering system would be designed and constructed to maintain the groundwater level 25 to 75 feet below the final pit bottom elevation of 4,525 feet.

The modeling for this SEIS estimates that an average of 32 gpm of water would have to be removed from the underground workings on an annual basis. In addition, the modeling indicates that pumping may not be required from the two existing highwall wells (PW-48 and PW-49), since evaporation and the heat produced by the reaction from sulfide oxidation would likely remove over 75 percent of the volume of this water as it migrated down the highwall. However, at least initially, the highwall wells would continue to be operated (GSM, 2002a). Operation requirements for the underground dewatering system would be less than the operation requirements for wells under the partial pit backfill alternatives. All water would be collected at one point.

4.2.4.5.2 Maintenance of Capture Points

The only capture point would be the sump in the underground workings. Access to the underground would be needed. The agencies have assumed highwall failures over time would bury the 4,550-foot elevation portal. The agencies would require GSM to submit a plan for development, maintenance and monitoring of a portal at a suitable elevation for long-term access. The agencies would bond for maintenance of access and regular repair and replacement of dewatering system components.

4.2.4.6 Storm Water Runon/Runoff Management

4.2.4.6.1 Maintenance Requirements

Storm water management maintenance requirements would be comparable to the No Pit Pond Alternative.

Surface water would be diverted around the open pit. Surface water that drains into the pit would be removed to the underground sump through bore holes drilled to connect the pit with the underground workings. As part of the final reclamation of the site, GSM would construct permanent storm water controls concurrently with site reclamation. These controls would minimize or eliminate surface water inflow from entering the open pit. More than 99 percent of the surface water would be diverted away from the pit (Telesto, 2003a).

Risks and uncertainties would be similar to the No Pit Pond Alternative.

4.2.4.7 Soil Cover

4.2.4.7.1 Soil Cover Maintenance Requirements

This alternative is similar to the No Pit Pond Alternative except there would be 1.3 fewer acres to maintain in the pit. Any rocks off the highwall that escape the safety benches may end up on the soil covered revegetated areas on pit roads and benches. These areas may either need to be cleared or resoiled and reseeded. There would be no backfill material, and therefore no cover on backfill material.

4.2.4.8 Water Treatment

This alternative would be similar to the No Pit Pond Alternative and an estimated 32 gpm would be pumped from the underground workings. Water quality in the underground sump would be more predictable than water in the backfill.

4.2.4.8.1 Additional Sludge Management Requirements

The agencies have assumed that the 32 gpm produced in the underground workings would be comparable to the water quality in the No Pit Pond Alternative. The amount of water needing treatment would be less than the 102 gpm used to design the water treatment plant capacity for the No Pit Pond Alternative in the 1997 Draft EIS.

The water quality used in the 1997 Draft EIS was better than the water quality used in this SEIS so additional sludge would be created. The agencies have concluded that the amount of additional sludge would be minimal and would not produce changes in the sludge management plans at the water treatment plant. Because no waste rock would be removed from the East Waste Rock Dump Complex to be used as backfill, jarosite, adsorbed metals, and other oxidation byproducts would remain relatively immobile in the waste rock dump complex.

4.2.4.8.2 Additional Operating Requirements

Pumping from the underground sump at the 4,450-foot elevation out of the 4,550-foot elevation portal and then to the water treatment plant would result in the need for some additional pipeline and powerlines over those needed for the No Pit Pond Alternative.

The agencies have assumed that the 4,550-foot elevation portal would be buried by rocks raveling and sloughing off the highwalls over time. GSM would be required to maintain access at a contingency portal location. This would require additional powerlines, pipelines and maintenance of access roads in the decline to ensure integrity of the dewatering system and provide a secondary escapeway for workers over time. The agencies have assumed the safety risk to workers in the pit is less than in the No Pit Pond Alternative. The risk to workers from using the underground sump for the dewatering system would be less than the risk to workers maintaining the pit dewatering system in the No Pit Pond Alternative.

4.2.4.9 Flexibility for Future Improvements

4.2.4.9.1 Potential for Utilization of New Technologies

The Underground Sump Alternative would have potential for utilization of new technologies being developed for use in the underground workings to collect or treat seepage. Access would have to be maintained to the underground workings to implement these new technologies or wells could be drilled into the underground workings. Research is being conducted on treating pit water with carbon sources, microbes, etc. in various locations around the world including the Berkeley Pit in Butte. It would be easier to implement treatment systems using chemicals, carbon sources, microbes, etc. in an open body of water in the underground sump than in a pit backfilled with waste rock.

The acidic water would cause regular maintenance and replacement of pumps and other dewatering well components, as in other alternatives. Although no waste rock is placed in the pit under this alternative, the water is still expected to be acidic because of its exposure to pit rock containing sulfides and the agency-assumed 200,000 cubic yards (300,000 tons) of rock that ravels and sloughs to the bottom over time.

GSM has been researching the potential to treat or at least pretreat pit water in situ. During 2002-2003, GSM added carbon sources such as alcohol and sugars to the pit in an attempt to pretreat the pit water in the rubble at the bottom of the pit. In addition, GSM is currently treating water that is collecting in the underground workings. This new test has been approved by the agencies (DEQ and BLM, 2004). Pretreating the pit water would increase the operational life of dewatering system components by reducing corrosion. Depending on the success of the test, it may cause potential biofouling and scaling.

This alternative offers the opportunity to test and potentially treat water either in an open pond or in an open water body in the underground workings. The agencies believe the potential for using new technologies is maximized in the Underground Sump Alternative.

4.2.4.9.2 Consequence of Failure

The consequence of failure of a dewatering system in the underground workings in this alternative would be that the underground workings below the pit would flood, and the pit would begin to fill with water. The consequence of failure would be similar to the Pit Pond Alternative, which was dismissed in Section 2.5.4. If the Underground Sump Alternative failed, then the No Pit Pond Alternative or a pit pond alternative could be implemented. Under the Pit Pond Alternative, the water table would rise to the 4,635-foot elevation and stabilize.

Under the No Pit Pond Alternative, 111,000 cubic yards (167,000 tons) of crusher reject would be backfilled. The agencies have assumed that up to 100,000 cubic yards (150,000 tons) of rock would ravel and slump off the pit highwall over time, and another

100,000 cubic yards (150,000 tons) would slough. Even with this volume of rock in the bottom of the pit, the water table would not rise above the 5,050-foot elevation where water would begin to discharge from the pit.

The Underground Sump Alternative would be similar to the No Pit Pond Alternative in terms of ravel and slough as well as water table stabilization level. Even with the rock that would ravel and slough to the pit bottom, the water level would stabilize below the 5,050-foot elevation (Telesto, 2003a). If the dewatering system was to fail and a pit pond formed, water could be treated in the pit, pumped to the treatment plant from the pit pond and treated, or the No Pit Pond Alternative could be implemented as a contingency. This alternative offers the most flexibility for future changes in water treatment methods.

4.3 ENVIRONMENTAL ISSUES

4.3.1 Environmental Impacts of Current Mining Operations

4.3.1.1 Waste Rock Impacts to Water Quality and Quantity

Springs around the pit area are shown in Figure 3-5. No impacts to spring water quality during mining operations were identified in the 1997 Draft EIS, Chapter IV, Section IV.B. Since 1998, the only documented change in water quality in pit area springs was to Stepan Spring. Stepan Spring below the South Dump showed water quality impairment, which was attributed to waste rock dump runoff (Gallagher, 2003b). This site has been reclaimed and water quality has improved, with pH returning to the range of 5.5 to 6.5, similar to that in 1989 (See Section 3.3.4). Stepan Original Spring emanates from a collapsed adit and represents regional groundwater that has traveled through mineralized zones (HSI, 2003).

The East Waste Rock Dump Complex buried an intermittent spring, Midas Spring, which may be associated with the buried Midas adit and possibly associated with the Sunlight slip block discussed by Golder (1995a). Discharge from this spring is believed to be in contact with waste rock, and the earliest measurements in 1990 indicate that it was acidic with elevated sulfate and metals. Midas Spring discharge is captured and conveyed to the water treatment plant.

Rattlesnake Spring and Bunkhouse Springs emerge in Rattlesnake Gulch, a natural drainage filled with debris flow and landslide deposits derived in part from mineralized portions of Bull Mountain. As described in Section 3.3.4, these springs receive flow from mineralized zones, which contain subsurface ferricrete deposits, and are believed to be representative of naturally mineralized groundwater. There are no definitive water quality trends indicating mining- or waste rock-related impacts (Gallagher, 2003a).

Arkose Valley Spring and Sunlight Spring were both covered by the West Waste Rock Dump Complex sometime after 1986, and do not have any surface expression. No discharge or seepage of water currently occurs from the West Waste Rock Dump Complex.

Storm water runoff from the waste rock dump complexes has been limited during mine life. Storm water that ran off was captured at the toe of the waste rock dump by berms and percolation ponds. No impacts have been noted in down stream monitoring wells (GSM 2003 annual report).

4.3.1.2 Pit Impacts to Water Quality and Quantity

4.3.1.2.1 Pit Impacts to Groundwater

As groundwater enters the pit, it flows through zones of broken and disturbed rock, which contains 0.5 to 2.0 percent pyrite. Atmospheric oxygen and dissolved oxygen in water percolating through the broken rock reacts with the pyrite, which leads to sulfide oxidation and generation of ARD. In addition, during precipitation events, water quality is degraded by the flushing of oxidation by-products, such as acid salts that have accumulated on the pit highwall from evaporation (Gallagher, 2003b) and from heat produced by sulfide oxidation.

As discussed in Section 3.3.3, water collected within the pit has been impacted by ARD during the life of the mine. Most of the seeps and springs emanating from the pit highwall have a pH ranging from 2 to 4 (Gallagher, 2003b). Freshly blasted highwall rock is primarily unoxidized and acid producing (Gallagher, 2003a; Schafer and Associates, 1994, 1996). GSM has conducted research on the pit sump water during operations. Water pumped from the pit sump from 2002 to 2003 had a median pH of approximately 4.5 and an average sulfate concentration of 16,400 mg/l.

Groundwater immediately up gradient of the pit is less affected by sulfide oxidation and is of better quality than pit water. Two wells (PW-48 and PW-49 as shown on Figure 3-5) located on the 5,800-foot elevation bench on the north highwall are continuously pumped to intercept groundwater up gradient of the pit. Monitoring results from these wells indicate that the water quality is relatively good for water in a sulfide mineralized zone (GSM, 2002a). The water quality from PW-48 is somewhat lower than PW-49, with median pH of 3.8 and median sulfate of 1,825 mg/l, compared to 5.9 and 1,605 mg/l, respectively for PW-49.

The 1997 Draft EIS, Chapter IV, Section IV.B.1.b indicated that ARD from the pit was not expected to impact local groundwater quality during mining operations. The 1997 Draft EIS concluded that mining would reduce the groundwater level around the pit area during operations. Pumping of water from the pit causes a cone of depression in the potentiometric surface of the bedrock aquifer surrounding the pit such that the net flow is into the pit creating a hydrologic sink (URS, 2001; Hydrometrics, 1995) (Figure 3-5 from GSM, 2002a).

Groundwater flows into the pit from all directions, controlled by geologic structures such as faults, fractures, dikes, and disturbed rock zones. The sources of pit inflows include direct precipitation over the pit, the local and intermediate groundwater systems, underground mine water, and groundwater released from storage (Telesto, 2003a). The groundwater capture zone of the pit extends from as little as 100 to 300 feet east and south of the pit rim to as much as 1,600 feet north of the pit rim (Telesto, 2003a). Hydraulic effects of the pit may extend greater distances from the pit along fracture zones.

As described in Section 3.3.7.2, faults and fractures control the permeability of the bedrock unit in the pit area, and act as the conduits of groundwater flow into the pit. From 1995 through 2001, 43 pit highwall seeps were cataloged by GSM, some of which may be duplicative due to the changing pit configuration and seep locations over time (Gallagher, 2003b). The most seepage was found as the pit intersected the Corridor

Fault. In general, while new seeps have been identified as the pit was deepened, total flow from seeps has not changed proportionately. Precipitation events were found to be responsible for the largest variations in pit highwall seep flows (Gallagher, 2003b). Gallagher (2003a) also described the geologic structural controls, lithologic controls, and engineering/blasting controls on pit highwall seepage. A disturbed rock zone caused by conventional blasting and mining extends several feet to tens of feet into the pit highwall. This zone tends to funnel pit highwall inflows downward, where the water may reach the pit bottom or emerge as pit highwall seeps.

The pit has been maintained as a hydrologic sink by pumping from the pit since at least 1991, when the first seeps developed during Stage 2 and 3 mining. Dewatering requirements were minimal until late 1991/early 1992 when the pit intercepted the Corridor Fault in the Stage 3 Pit. In July 2002, GSM installed a dewatering well in rubble in the bottom of the pit. The well was constructed to a depth of approximately 118 feet (bottom of hole elevation 4,748 feet). The well was pumped routinely from the end of July 2002 until July 2003 to keep the water level below the pit floor. In July 2003, the well was removed to allow mining of the rubble in the bottom of the pit. Based on pumping records, water inflow to the sump at the bottom of the pit averaged 27 to 30 gpm while the well was in service.

Two highwall wells (PW-48 and PW-49) are continuously pumped to intercept groundwater from the Corridor Fault area before it enters the pit. In 2002-2003, the combined flow from these wells averaged approximately 18 gpm (PW-49 averaged 16 gpm, PW-48 averaged 1 to 2 gpm). In addition to the existing dewatering wells, horizontal drains are installed and incorporated into the dewatering system as required to maintain safe operations. Less than 5 gpm of groundwater discharges into the underground mine and is collected in the underground sump and pumped out of the underground. The underground sump at the 4,650-foot elevation has a 500,000 gallon capacity.

Since the 1997 Draft EIS was published, water levels in wells near the pit have shown a strong downward trend as a result of regional drought conditions and pit dewatering (HSI, 2003; SEIS Figure 3-6). Water levels in R-18 declined from late 1997 until the monitoring well was mined out in September 1999.

The average annual total pit pumping rates for 2000, 2001, and 2002 were 36.4, 28.2, and 47.8 gpm, respectively (Gallagher, 2003a). The average annual total pit pumping rate for 2003 was 36 gpm (GSM, 2004b). Prior to 2000, monthly average pit pumping rates varied from 12 to 76 gpm (Hydrometrics, 2000). The 1997 Draft EIS, Chapter IV, Section IV.B.1.b reported that the minimum groundwater elevation in the pit in 1993 was approximately 5,400 feet. In 2002, the minimum pit groundwater elevation was approximately 4,700 feet. GSM is permitted to mine the pit to the 4,650-foot elevation, and the pit reached that depth in October 2003.

The hydrograph study found that there was a general decline in bedrock water levels since 1998, but that it was difficult to make definitive conclusions regarding the causes

(HSI, 2003). A decline in precipitation from 1998 into 2003 was found to have affected groundwater levels in bedrock wells at GSM. However, the general water level declines track with the trend of R-18 reasonably well, indicating that pit dewatering may be responsible for some portion of water level declines in the fractured bedrock aquifer, particularly in PW-14, located about 3,000 feet northwest of the pit.

During mine operations and during the 16 to 18-month mill shut down while Stage 5B waste rock is being removed, water collecting in the pit bottom is transferred to the underground workings through drill holes that intercept both the underground workings and pit. This water currently collecting in the underground workings can be either sprayed over blasted rock to control dust or pumped to a lined holding pond and then to the water treatment facility. The water from the highwall dewatering wells is mixed with treatment plant discharge and directed to the LAD infiltration basin, a lined pond for treatment, or Tailings Impoundment No. 2.

In summary, mining has caused a decline in the groundwater level around the pit area. This condition would continue through Stage 5B. The regional drought has contributed to the decline in groundwater level (HSI, 2003). The regional drought may have also contributed to reduced levels of pit inflow as well as reduced estimates of water needing treatment.

4.3.1.2.2 Pit Impacts to Surface Water

The 1997 Draft EIS, Chapter IV, Section IV.B.1.b reported that discharges at springs and seeps in the vicinity of the pit have the potential to be impacted if the expanding cone of depression from pit dewatering intercepts interconnected hydrogeologic units and groundwater, which otherwise would discharge to the surface as springs. Because of the small (0.2 gpm to 25 gpm) variable spring flow rates and the complex nature of the hydrostratigraphic units, incremental changes in spring discharge have not been quantified. The 1997 Draft EIS, Chapter III, Section III.B described the setting and general conditions for each of the known springs around the pit area, including Bunkhouse, Rattlesnake, Stepan, Stepan Original, and St. Paul springs (Figure 3-5). The long-term potential impact to Stepan Spring, identified as most likely to be impacted by pit dewatering, was a reduction in flow. This reduction could bring the flow from the current range of 0.8 to 2.8 gpm to a range from 0.1 to 1 gpm. Other springs could be expected to have a smaller reduction in flow. If the groundwater cone of depression has not reached equilibrium at the conclusion of mining, long-term impacts to springs from pit dewatering may be somewhat greater than the impacts of current operations, and monitoring and mitigation Measure W-1, approved in the 1998 ROD as Stipulation 010-4, would continue.

The trend of spring flows since 1998 was reviewed, and all but one spring was found to exhibit at least a slight decline in flow (HSI, 2003). The flow of Rattlesnake Spring increased slightly. Springs having a slight to moderate decline included Bunkhouse, Sheep Rock, Stepan Original, Stepan, and St. Paul. With springs at long distances from the pit, such as St. Paul and Sheep Rock springs, exhibiting as much or more relative decline in flow as those much closer to the pit, it was concluded that the drought had likely been the dominant factor leading to declining spring flows (HSI, 2003). Since 1998, annual precipitation recorded at the mine has averaged 2.39 inches below normal per year. Onsite precipitation monitoring for 1985 to 2003 averaged 13.69 in. Since 1998, precipitation has been 10.9 inches in 1999, 11.3 inches in 2000, 9.58 inches in 2001, 11.61 inches in 2002 and 13.09 inches in 2003.

In summary, observations and measurements of springs since 1998 generally support the findings of the 1997 Draft EIS regarding impacts of pit dewatering, namely, that there may have been slight reductions in flow in some of the springs closest to the pit, and those with a potential hydrologic connection to the pit, including Rattlesnake Spring, Bunkhouse Springs, Stepan and Stepan Original Springs, Sunlight Spring and Arkose Valley Spring (the last two are covered by the West Waste Rock Dump Complex). However, no flow reductions have been found beyond those associated with drought. Additional spring flow reductions from pit dewatering are anticipated from the continuation of mining operations through Stage 5B.

Monitoring of springs since 1998 has not shown changes in water quality, but drought may have complicated interpretation of data (HSI, 2003).

4.3.2 No Pit Pond Alternative (No Action)

4.3.2.1 Impacts to Groundwater Quality and Quantity

4.3.2.1.1 Risk of Impacts to Groundwater Quality and Quantity in Permit Area

The most important issue related to pit reclamation at GSM is impact to groundwater. The 1997 Draft EIS, Chapter III, Section III.B.2 included a discussion of the regional and local groundwater resources. The 1997 Draft EIS, Chapter III, Section III.A also contained a description of the geochemistry of the ore and waste rock. In the 1997 Draft EIS, Appendix A, Table 1, groundwater quality in the backfilled pit was assumed to be an average of Ohio Adit, Stage 2 pit sump, Stage 3 pit sump, highwall seep, and water treatment plant feed water. In this SEIS, Section 3.3 presents updated geochemical information (Telesto, 2003c). In this SEIS, the projected pit water quality has been updated based on West Waste Rock Dump Complex pore water sampling and other geochemical samples taken from around the site that emanate from similar materials that may be undergoing similar processes as the pit backfill. This water quality is worse than that used in the 1997 Draft EIS (see Table 4-5 in Section 4.3.3.1).

The 1997 Draft EIS, Chapter IV, Section IV.B relied on numerical groundwater model simulations of the local pit groundwater system conducted in 1995 as the primary basis for evaluating impacts to water quantity from pit dewatering (Hydrometrics 1995). A detailed discussion of the groundwater model configuration and input parameters can be found in Volume 3, Appendix 4.7-1 of GSM's Permit Application (GSM 1995b). Additional studies were performed for this SEIS, including a pit hydrogeology investigation (URS, 2001), a pit highwall seep study (Gallagher, 2003b), a new water balance model of the pit (Telesto, 2003a), and an analysis of well and spring hydrographs (HSI, 2003), and are discussed in Section 3.3.6.

Several factors of the pit reclamation plan that could affect groundwater resources include:

- Seepage from 13 percent of the East Waste Rock Dump Complex in Rattlesnake Gulch;
- Geochemistry of the backfill material and the effects on groundwater quality;
- Changes in water quality in the saturated zone in the backfill material;
- Amount of water entering the pit after closure; and,
- Ability to dewater the reclaimed pit.

4.3.2.1.1.1 Impacts from Waste Rock Dump Seepage

The East Waste Rock Dump Complex contained 76,700,000 cubic yards (114,750,000 tons) of waste rock in December 2003. Mining of Stage 5B would add approximately

25,000,000 cubic yards (37,500,000 tons). The total volume of the East Waste Rock Dump Complex would then be 101,700,000 cubic yards (152,250,000 tons). The characteristics of the waste rock from Stage 5B would be similar to that existing in the East Waste Rock Dump Complex.

Under the No Pit Pond Alternative, up to 500,000 cubic yards (750,000 tons) would have been removed from the top of the East Waste Rock Dump Complex for the backfill sump (1997 Draft EIS, Chapter II, Section II.B.6.b; 1998 ROD). Based on the revised pit design in this SEIS under the No Pit Pond Alternative, only 111,000 cubic yards (167,000 tons) would be removed from the top for backfill. This is about 0.1 percent of the total waste rock volume and would not change the footprint of the dump (Figure 2-5, showing waste rock after Stage 5B).

The 1997 Draft EIS, Appendix J evaluated waste rock dump water quality. A numerical model was developed and simulations performed to assess the ultimate extent and timing of impacts to water quality that could be caused by ARD from the waste rock dumps. The analysis for this SEIS performed a review of the methods and key parameters of the 1997 Draft EIS modeling, assembled updated information where available, applied methods of analysis consistent among the alternatives, and checked for differences in findings or conclusions that could affect the rating or selection among SEIS alternatives (HSI, 2003).

4.3.2.1.1.1.1 Estimation of Long-Term ARD Production by Waste Rock Dump Complexes

The long-term quality of water discharge from the toe or base of a waste rock dump is controlled by the flow of water through the waste rock dump materials, the availability of oxygen, and the abundance of sulfide minerals and/or oxidation byproducts in the waste rock. These processes were described in detail in Appendix I of the 1997 Draft EIS. The focus of ARD impact analysis from waste rock dumps is two-fold:

- The hydrology of water infiltration through the waste rock, transport downward to the aquifer, and then down gradient through groundwater aquifers to the mixing zone boundary and receiving surface waters; and,
- The generation, transport and attenuation of the contaminants, principally acidity and metals, contained in the seepage.

The existing reclamation plan provides for covering all 2H:1V slopes on waste rock dump surfaces with 3 feet of cover soil having greater than 45 percent rock content and revegetation. This plan has not been approved for pit reclamation (DEQ and BLM, 2003). The reclamation cover is designed to limit water infiltration, thus minimizing the production and migration of ARD through the waste rock dumps.

As described in the 1997 Draft EIS, Chapter IV, Section IV.C, capping measures aimed at reducing water infiltration rates would reduce pollutant load in the short term. Based on the results from long-term ARD studies conducted at other sites, the rate of ARD generation may be reduced by reclamation, but cannot be eliminated (Telesto, 2003c). For a range of potential infiltration rates the long-term ARD load would be expected to be similar. For this reason, ARD impact analysis focuses on the fate and attenuation of contaminants over a range of possible hydrologic conditions, assuming that ARD generation cannot be fully prevented.

4.3.2.1.1.1.2 Water Balance of the East Waste Rock Dump Complex

In the 1997 Draft EIS, Chapter IV, Section IV.B.1.a, three modeling approaches were used to provide an assessment of the water balance within reclaimed dumps at GSM:

- Hydraulic Evaluation Landfill Performance model (HELP) (Schroeder et al., 1994);
- A model by Schafer Limited (2001); and,
- SOILCOVER model (Swanson, 1995).

These models use soil, climate, vegetation, and other information to establish a water budget. A variety of parameters considered in each model addresses the manner in which water on the waste rock dump surface can be removed by evapotranspiration and runoff. Water that is not removed by evapotranspiration and runoff is available to enter the waste rock dump interior by percolation.

All three model calculations in the 1997 Draft EIS were in general agreement and suggested that infiltration through the reclaimed dump surface would be on the order of 0.25 inch per year, which is about 1.7 percent of the 13.75 inches of annual precipitation incident to the dump surface area. The studies found that infiltration might be as high as 0.5 inch in wet years. Seepage from the East Waste Rock Dump Complex for 0.25 inch of infiltration was estimated to be about 10.5 gpm (Appendix J, 1997 Draft EIS).

Since the 1997 Draft EIS, updated estimates of infiltration on waste rock dumps at GSM became available with the completion of a technical report covering eight years (1992-2000) of hydrologic monitoring and reclamation of the West Waste Rock Dump Complex (Schafer Limited, 2001). Schafer Limited (2001) addressed ARD generation potential, oxygen and water movement, water balance, temperature, and water quality of the West Waste Rock Dump Complex. Although the West Waste Rock Dump Complex is not involved in any of the alternatives or actions in this SEIS, the technical analysis found it to be a surrogate for the East Waste Rock Dump Complex, thus providing a check on the modeling estimates done for the 1997 Draft EIS (Telesto, 2003c).

The average infiltration rate into revegetated portions of the West Waste Rock Dump Complex was 1.1 inches/year (Schafer Limited, 2001). This is greater than the HELP model study in the 1997 Draft EIS, which was 0.25 inch/year (best case) to 0.5 inch/year (expected case) on reclaimed surfaces, and less than 2 inches/year on unreclaimed surfaces (Schafer Limited, 2001). Not all of the infiltration measured in his study led to a continuing saturation of the dump materials, for the following reasons:

- Oxidation of pyrite consumes 3.5 moles of water for every mole of pyrite oxidized, chemically consuming water which therefore cannot flow out of the dump;
- Ferrihydrite, formed as a by-product of pyrite oxidation, has a greater capacity to retain water than the original pyrite;
- Heat produced by pyrite oxidation causes upward movement of air within the waste rock dump, particularly in winter. Cold dry air is pulled into the toe of the dump and is warmed as it flows through the interior, where it becomes water-saturated before exiting the top of the dump. Water vapor may also be expelled from the dump via latent heat transport (warm air is capable of greater moisture transport than cold air) and through water vapor transport. Evidence of heat and water vapor movement of these types has been seen at GSM; and,
- The percolation rate is lower than the saturated permeability, therefore not allowing saturated conditions to occur.

The average infiltration rate (1.1 inches/year) was a gross value, while the values used in modeling the East Waste Rock Dump Complex in the 1997 Draft EIS were net values (Schafer Limited, 2001). The difference was attributed to consumption of water by pyrite oxidation, water retention by ferrihydrite, and water loss from the dump via convective air flow. The processes described above should prevent flux of water through the pile for at least 20 to 50 years. The 1997 Draft EIS analysis in Appendix J provided modeling output graphs (Figures J-3 to J-24) which incorporated “best case”, “expected case” and “worst case” ARD scenarios, with infiltration rates of 0.25, 0.50 and 2.0 inches/year, respectively. The 1997 Draft EIS modeling incorporated the range of infiltration measured, and is considered a valid estimation of the expected long-term infiltration rate to groundwater through the East Waste Rock Dump Complex.

Beginning in November 2001, GSM sponsored another reclamation cover infiltration monitoring study within the East Waste Rock Dump Complex (Nichol and Wilson, 2003). Continuous monitoring of soil moisture at five different depths within the soil cover and upper portions of the waste rock (23 to 145 cm) indicated that the water movement was generally upward, and that net infiltration had not occurred during 2002.

Evaluation of long-term infiltration estimates for soil covers at GSM found that approximately 0.25 to 0.5 inch/year of net infiltration occurred (Telesto, 2003e). For the purposes of assessing the middle to worst-case hydrologic impacts in this SEIS, a rate of 0.5 inch/year was determined to be the best estimate of net long-term infiltration for reclaimed waste rock dumps, with sensitivity evaluation up to 1.1 inches/year.

Impacts of ARD quality and quantity from the East Waste Rock Dump Complex were reevaluated in this SEIS and were similar to those identified in the 1997 Draft EIS. The following section addresses East Waste Rock Dump Complex ARD from the 13 percent of the dump complex that is in the Rattlesnake Gulch drainage (Figure 3-7).

The methodologies used in the 1997 Draft EIS were reviewed and determined to be a reasonable and generally acceptable basis for the analyses and purposes of this SEIS, with some qualifications (HSI, 2003). These qualifications included:

- Although the methodology for the cell-by-cell ARD transport and attenuation modeling of the 1997 Draft EIS, Appendix J was described, a working version of the model was not available, so an alternate approach was used in this SEIS. Termed “pore volume attenuation”, this approach is analogous to determining how much spilled milk (contaminants) a sponge (the aquifer) can absorb before dripping (releasing contaminants). In this methodology, the attenuation capacity (i.e., the ability for a portion of the aquifer to retard or completely restrict the movement of chemical mass) of the aquifer flow path was quantified through geochemical estimations. Attenuation capacity is measured in terms of the mass of a chemical constituent per mass of the aquifer. Knowing the saturated water volume (i.e. pore volume) per mass of aquifer and the concentration of constituents in the pore water, a calculation of how many pore volumes it takes to move an amount of constituents equal to the attenuation capacity was made;
- Only limited information on the calcite content of the Bozeman Group aquifer could be found, indicating calcite levels of less than 5 percent (the content used in the 1997 Draft EIS). The pore volume method eliminated the need for direct use of this parameter;
- The correlation of metals to predicted sulfate concentrations, as used in the 1997 Draft EIS analysis, was acknowledged to be simplistic, and not sensitive to differences among the alternatives. Again, the pore volume method eliminated the specific need for this correlation; and,
- This SEIS evaluation used updated values for some of the parameters in the fate and transport equations of Appendix J, and revised some of the 1997 Draft EIS predictions to be consistent with this information.

The 1997 Draft EIS, Appendix J, provided a discussion of the limitations and assumptions of the ARD fate and transport modeling. These also apply to this SEIS analysis, and can be summarized as follows:

- The model simplified complex hydrogeological and geochemical processes;
- There is some degree of error within the model predictions due to uncertainty in the model input parameters;
- The model is intended to characterize, compare, and contrast the types of possible impacts, not to accurately quantify those impacts; and,
- These impacts may or may not occur depending on future site-specific conditions such as long-term climatic conditions, infiltration rates, and oxidation rates, in addition to other physical conditions which are difficult to quantify such as moisture migration pathways, rate of groundwater movement and flow paths, and subsurface geochemical conditions.

A review was made of the key parameters that are required to be used in the hydrology fate and transport equations (HSI, 2003). Some of the parameters were estimated for the 1997 Draft EIS and were measured in studies specifically at GSM, for example porosity was estimated to be 26 percent in 1997 but was measured at 4 to 10 percent in two recent studies at GSM. This SEIS evaluation focused on using a consistent approach in the sources and application of parameters among the alternatives. There was some emphasis on defining the "worst case" scenarios for the parameters to ensure that decision makers had information on the sensitivity of the estimates. Table 4-4 provides a comparison of the key modeling parameters from the 1997 Draft EIS, Appendix J, along with updated information and estimates used in this SEIS.

In the 1997 Draft EIS, Chapter IV, Section IV.B.1.a, the potential impacts from the East Waste Rock Dump Complex were evaluated for the Bozeman Group aquifer, upon which most of the waste rock dump rests. This was extended in this SEIS to include the 13 percent of the East Waste Rock Dump Complex that overlies the Tdf/colluvial aquifer of Rattlesnake Gulch. Details of the updated ARD fate and transport model of the East Waste Rock Dump Complex conducted for this SEIS are presented in HSI (2003).

The total time for East Waste Rock Dump Complex seepage in Rattlesnake Gulch to travel through the Tdf/colluvial aquifer was not estimated in the 1997 Draft EIS. In this SEIS, the total time for East Waste Rock Dump Complex seepage from the portion in Rattlesnake Gulch to travel through the Tdf/colluvial aquifer was estimated at 80 to 190 years (HSI, 2003).

Table 4 - 4 Comparison of Key Parameters in ARD Modeling For the East Waste Rock Dump Complex over the Rattlesnake Gulch Drainage, EIS to SEIS[1]

East Waste Rock Dump Complex Parameter	1997 Draft EIS Appendix J	End of Stage 5B	Comments
Waste rock thickness	Up to 300 feet	Up to 300 feet	Approx. 222 acres of East Waste Rock Dump Complex would have up to 100 feet of waste rock removed in the backfill alternatives (about 33% of the volume)
Infiltration	0.25 - 2 inches/year	0.5 - 1.1 inches/year	Revised based on study of the West Waste Rock Dump Complex (Schafer Limited, 2001)
Recharge in undisturbed areas	1.5 inches/year	0.25 – 0.5 inch/year	Golder (1995a) water balance of Sunlight Block
Width of flow path	4,000 feet	3,300 feet	As mapped 2003
Thickness of flow path	Graded from 100 - 300 feet	150 feet	Based on observed depth of constituents below Tailings Impoundment No. 1

Length of flow path in Bozeman Group aquifer	13,200 feet	12,500 feet	Measured from toe of dump
Groundwater base flow rate in the Rattlesnake Gulch drainage	200 gpm	52-103 gpm	Flow rate reduced based on HSI 2003
Effective porosity	26%	4%-10%	Herasymuik, 1996 and Schafer Limited, 2001
Specific retention	8%	5.5%	Schafer and Associates (1995) for the East Waste Rock Dump Complex
Permeability, Bozeman Group aquifer	1.2x10^{-6} cm/sec (vertical); 2.5x10^{-4} cm/sec (horizontal)- est.	2.5x10^{-5} cm/sec	Upper estimate of bulk permeability
Amount of calcite	5 percent	Not used directly	Used pore volume attenuation method
Sulfate concentration	30,000 mg/l	Not used directly	Used pore volume attenuation method
Mass of sulfide in dump	0.5 – 2 percent sulfide	Not used directly	Used pore volume attenuation method
Concentration of metals	Correlated from Schafer and Associates (1994)	Not used directly	Used pore volume attenuation method
Impacted aquifers	Bozeman Group aquifer	87 percent Bozeman Group aquifer, seepage of 8-18 gpm; 13 percent Tdf/ colluvial aquifer, seepage of 1-3 gpm	Based on updated aquifer mapping (HSI, 2003)
Thickness of unsaturated zone in Bozeman Group aquifer	200 feet	80 feet	

[1] *From HSI, 2003 as updated by the agencies*

The 1997 Draft EIS, Chapter IV, Section IV.B.1.e predicted that the base flow captured below Tailings Impoundment No. 1 in Rattlesnake Gulch would be 200 gpm. The agencies assumed the 10.5 gpm of East Waste Rock Dump Complex drainage would report to the Bozeman Group aquifer and be attenuated. Based on this SEIS analysis, there is reduced flow in the Rattlesnake Gulch drainage of 52 to 103 gpm (HSI, 2003). One to three gpm of the East Waste Rock Dump Complex drainage would report to the Tdf/colluvial aquifer. Therefore, the 8 to 18 gpm drainage from the rest of the East Waste Rock Dump Complex is within the range of the 1997 Draft EIS analysis and mitigation Measure W-4, Stipulation 010-7 in the 1998 ROD. It is also within the contingency volume of water to be treated from the East Waste Rock Dump Complex under the No Pit Pond Alternative.

A Dynamic Systems Model (DSM) was utilized by Telesto (in HSI, 2003) to predict the water quality impact of seepage from the 13 percent of East Waste Rock Dump Complex expected to reach the Tdf/colluvial aquifer. Based on the expected average infiltration rate of 0.5 to 1.1 inches/year on the East Waste Rock Dump Complex, the long-term seepage rate after reclamation from the East Waste Rock Dump Complex was estimated at 9 to 21 gpm. The portion of this seepage expected to reach the Tdf/colluvial aquifer would be about 1 to 3 gpm. The GSM Attenuation Study (Telesto, in HSI, 2003) indicated that a solution of mixed Tdf/colluvial aquifer groundwater and East Waste Rock Dump Complex seepage would have 13 to 15 pore volumes of attenuation capacity in the Tdf/colluvial aquifer, at the net infiltration rate of 0.5 inch/year. Given the anticipated range of flows in the Tdf/colluvial aquifer (52 to 103 gpm), attenuation of exchangeable metals could be expected for 35 to 63 years. Some contaminants such as sulfate, arsenic and zinc have little affinity for attenuation, and would not be removed in transport. Because the water flow rate from net infiltration through the East Waste Rock Dump Complex is small compared to the entire flow through the aquifer, the time required to fill the attenuation capacity of the aquifer is directly proportional to the mass load into the aquifer. A net infiltration rate through the pile of 1.1 inches/year would increase the mass loading by roughly 2.2 times. Thus, the attenuation capacity would be exhausted approximately 2.2 times faster, and the resulting range would be from 16 to 29 years.

The results of the updated long-term fate and transport evaluation of the East Waste Rock Dump Complex led to the following conclusions about impacts to groundwater quality and quantity in the permit area:

- The 1997 Draft EIS said 10.5 gpm would seep from the East Waste Rock Dump Complex. Long-term hydrologic monitoring and reclamation studies at GSM indicate that the best estimate of average long-term net infiltration rate to reclaimed rock dumps is 0.5 inch/year, with the gross infiltration rate of 1.1 inches/year, yielding seepage rates from the East Waste Rock Dump Complex of 9 to 21 gpm (Schafer Limited, 2001; Telesto 2003e). Eight to eighteen gpm would travel down the main waste rock flow path; and,
- Based on updated hydrogeologic data, the thickness of the unsaturated zone of the Bozeman Group rocks beneath the East Waste Rock Dump Complex is typically 80 feet, compared to the 200 feet used in the 1997 Draft EIS. This shortens the time for breakthrough of ARD to the Bozeman Group aquifer.

It is possible to estimate the rate at which pyrite and other sulfide minerals are oxidizing by monitoring the internal temperature of the dump (Harries and Ritchie, 1987). Monitoring conducted on the West Waste Rock Dump Complex showed that the unreclaimed portion of the complex had a higher average temperature than the reclaimed portion (Schafer and Associates, 1994). The data indicated that the cover provided no definitive control on oxidation rates (Bennett, 1997).

Water is consumed geochemically during the oxidation of sulfide minerals in the waste rock dump complexes. Additionally, the oxidation of sulfide minerals raises the internal temperature of the dumps and appears to produce a chimney-like effect where cool air is drawn in the sides of the waste rock dumps and hotter, moister air exits through the top. This effect ensures a continued supply of oxygen for sulfide oxidation, but also can act to remove water from the dump interior in the form of water vapor. As much as 5 inches of water per year were reported to be removed by this convective mechanism

(1997 Draft EIS, Chapter IV, Section IV.B.1.a). To be more protective of groundwater quality, modeling for the 1997 Draft EIS and this SEIS assumed that no water was removed by this convective mechanism. The agencies have assumed that the convective mechanism would eventually stop and water would exit the dump as seepage.

4.3.2.1.1.1.3 Long-Term Monitoring and Mitigation for Unanticipated East Waste Rock Dump Complex Seepage

As pointed out in the 1997 Draft EIS, Chapter IV, Section IV.B.1.a, it is possible that ARD-contaminated groundwater could travel through high conductivity preferential flow paths down gradient from the East Waste Rock Dump Complex. In addition, the water infiltration rate through the waste rock dumps could be higher than estimated, resulting in a greater flow rate of ARD than anticipated. As a contingency, potential monitoring and mitigation measures to control and contain unanticipated ARD in groundwater under the No Pit Pond Alternative are required by Stipulation 010-7 that was approved in the 1998 ROD. Table 4-2 shows the water treatment plant was designed to treat up to 25 gpm of East Waste Rock Dump Complex seepage. Appendix B, Section 6.0 of the 1997 Draft EIS, contains a GSM commitment to further hydrogeologic investigation of the waste rock dump complexes to identify optimum monitoring sites and to aid in the design of groundwater capture systems if needed as contingencies for waste rock dump seepage. In addition, GSM has committed to construct additional monitoring wells along the waste rock dump perimeters as part of the long-term monitoring plan. A final mixing zone compliance monitoring plan will include additional wells along the approved mixing zone boundaries as identified in consultation with DEQ. As a result of this SEIS reevaluation, no additional mitigation measures are needed.

4.3.2.1.1.1.4 Summary of East Waste Rock Dump Complex Seepage Impacts to Water Quality and Water Quantity

No impacts to groundwater quality from the portion of the East Waste Rock Dump Complex in Rattlesnake Gulch are anticipated during active mining operations through Stage 5B. An updated evaluation in this SEIS of the 1997 Draft EIS modeling using combinations of middle to worst-case parameters predicts that groundwater below the East Waste Rock Dump Complex would first experience ARD impacts in 33 to 72 years rather than in 844 to 1,223 years as predicted in the 1997 Draft EIS, but to a similar degree.

4.3.2.1.1.2 Impacts from Pit Seepage

4.3.2.1.1.2.1 Impacts to Water Quality

Water quality in the pit under the No Pit Pond Alternative would be characteristic of ARD, similar to that produced by mining operations. Only 111,000 cubic yards (167,000 tons) of waste rock backfill would be used to create the sump in the bottom of the pit.

This sump would prevent a pond from forming in the bottom of the pit (Figure 2-3 showing pit after backfilling).

Backfill in the sump could affect pit water quality. The 1998 ROD did not specify a source of backfill material. There are two potential on-site sources of suitable backfill material proposed by GSM (GSM, 2002a). One possible source of material is stockpiled mixed waste that was originally intended for reclamation of the waste rock dump complexes. Mixed waste consists of both sulfide and oxide waste rock. Another potential source is crusher reject material, which is proposed for use by GSM. Due to the screening process, this material is fairly uniform in size, with an average size of 2 inches or smaller, which would provide a relatively high porosity. Testing of these backfill sources was performed by GSM for this SEIS under a sampling and analysis plan (SAP) approved by the agencies (Telesto, 2003g, 2003h; GSM, 2003a). The acid-base accounting tests found that the mixed waste and crusher reject both had negative net neutralization potential (NNP). The mixed oxide material had a NNP of -12, and the crusher reject had a NNP of -113. These materials had little to no neutralization potential and pH values from leaching tests ranged from 4.4 to 7.4. In a pit backfill setting, both materials would generate ARD. The pit in its current configuration produces water in pH ranges similar to those from the leaching tests. The agencies assume that crusher reject would not change the quality of water needing treatment.

The agencies considered the use of other rock materials for the sump and concluded that they would decompose or become cemented in the saturated zone relatively quickly and would be no better than the waste rock or crusher reject for use as sump material over time.

In the 1997 Draft EIS, Appendix A, Table 1, groundwater quality in the backfilled pit was assumed to be an average of Ohio Adit, Stage 2 pit sump, Stage 3 pit sump, highwall seepage, and water treatment plant feed water. Pit sump monitoring by GSM in 2002 and 2003 has provided water quality data for the pit waste rock (GSM, 2002a; Telesto, 2003a). In 2002-2003, field pH ranged from 3.6 to 5.7, TDS ranged from 13,000 to 28,000 mg/l, sulfate from 9,370 to 20,400 mg/l, and dissolved copper from 0.7 to 12.2 mg/l (GSM, 2003e, 2004b). Other dissolved metals were also elevated. GSM's experience with pit water has shown that regular pumping from the pit sump or well reduces water quality degradation, primarily by limiting contact time with waste rock. Some of the water quality data in this period may not be representative because GSM conducted field experiments involving additions of organic carbon to the pit sump (S. Dunlap, GSM, personal communication, 2003).

Under the No Pit Pond Alternative, regular pumping would remove pit water from the backfill sump and send it to the water treatment plant. Regular pumping would maintain the pit as a sink, with a cone of depression in the potentiometric surface centered on the pit, similar to that which presently exists (Figure 3-5 in GSM, 2002a). No impacts to groundwater or surface water outside the pit would be anticipated because groundwater would not flow out of the pit. This agrees with conclusions in the 1997 Draft EIS.

If ARD inflows to the pit exceed the expected rates or the quality changes, Measure W-6 approved in the 1998 ROD as Stipulation 010-9 would apply. This measure provides for a re-evaluation of the water treatment plant capacity 2 years prior to mine closure, with modifications to the existing plant, or new treatment processes added for specific facilities, as may be required. Increased flows to the pit are not expected, based on observations during underground mining at GSM.

4.3.2.1.1.2.2 Impacts to Water Quantity

The No Pit Pond Alternative in the 1997 Draft EIS, Chapter IV, Section IV.B.6 considered impacts associated with pumping water from the pit sump, and focused on the quantity of water to treat and discharge. A pit water balance model was developed with the information available at that time (Hydrometrics 1995), which accounted for total inflows and outflows (see 1997 Draft EIS, Table IV-5). That model found that complete dewatering of the pit to the projected 4,700-foot-elevation pit floor at that time would require removal of approximately 102 gpm. Consequently, the 1997 Draft EIS concluded that water treatment requirements would have been greater under the No Pit Pond Alternative as compared to the Partial Backfill Alternative at that time, which would have required treatment of 50 gpm (1997 Draft EIS, Chapter IV, Section IV.B.7.b).

Based on GSM's experience in dewatering the pit for the past 5 years and a new pit water balance model, lower pit water inflows are projected for the No Pit Pond Alternative (Telesto, 2003a). The new model was calibrated to recent pumping records and predicts that pit dewatering would require perpetual removal of about 32 gpm. The hydrogeologic and water balance studies performed for this SEIS have shown that most of the water enters the pit through seepage from the Corridor Fault and through other faults in the upper half of the pit (Gallagher, 2003b; Telesto, 2003a). Faults penetrating the lower portions of the pit do not yield as much water. The underground mine, which is approximately 300 feet (4,400-foot elevation) beneath the current pit bottom has less than 5 gpm of inflow, based on visual observation during mining activities. Water was imported to maintain underground mining operations (HSI, 2003). Therefore, standard hydrogeologic modeling, which predicts that pit inflows would continue to increase as the pit deepens, does not apply. The new studies also found that most pit inflows were related to direct precipitation on the pit, and that more water is lost through evaporation than was previously suspected. The amount of water lost as a result of being heated and expelled as steam or warm vapor from the reaction of sulfides with water and oxygen (sulfide oxidation) was not quantified.

As stated in Section 4.3.2.2.2.2, the agencies have assumed that maintaining the pit as a hydrologic sink under the No Pit Pond Alternative would provide complete control of the ARD produced by the pit at its source and eliminate the risk of water quality impacts outside the pit.

4.3.2.1.1.2.3 Summary of Pit Impacts to Water Quality and Water Quantity

The analysis of this SEIS generally supports the findings of the 1997 Draft EIS for the

No Pit Pond Alternative, except that the long-term pumping rate would be approximately 32 gpm, instead of 102 gpm. The impacts to water quantity from the open pit after closure would likely be limited to possible reductions in flows of springs close to and hydrologically connected to the pit, i.e., Stepan, Stepan Original, Rattlesnake, and Bunkhouse springs, as a result of pit dewatering. Even if drought conditions have reduced pumping rate predictions, the water treatment plant would be built to treat the 102 gpm analyzed in 1997.

Because the pit would be maintained as a local groundwater sink and all pit water would be collected and routed to the water treatment plant before being discharged, no impacts to groundwater quality from pit outflows are anticipated long term.

Potential additional water quantity impacts from the No Pit Pond Alternative would likely be limited to possible reductions in the bedrock aquifer groundwater level. The groundwater level around the pit would be permanently drawn down. This is an unavoidable impact of controlling all groundwater flow out of the pit by maintaining the pit as a hydrologic sink. This could result in reductions of flows from springs around the pit as described in Section 4.3.2.2.1.2.

4.3.2.1.2 Risk of Violation of Groundwater Standards at Permit Boundary and Impacts to Beneficial Uses of the Jefferson River Alluvial Aquifer

4.3.2.1.2.1 Impacts from Waste Rock Dump Seepage

The Tdf/colluvial aquifer groundwater and the East Waste Rock Dump Complex seepage would migrate down gradient and mix with 99 gpm in the Jefferson River alluvial aquifer, the portion of flow within the GSM mixing zone. Following exhaustion of the attenuation capacity, the DSM indicated that this mixed groundwater would not exceed groundwater quality standards for any of the metals and trace elements modeled (arsenic, cadmium, copper, nickel, selenium and zinc) (HSI, 2003). The predicted nickel concentration, at 60 percent of the standard (0.1 mg/l), came closest to violating water quality standards. The evaluation indicated that the results were sensitive to the initial concentrations in the Tdf/colluvial aquifer, and to the mixing rate. In comparison, the 1997 EIS, Chapter IV, Section IV.B.1.a found that long-term impacts to groundwater in the vicinity of the waste rock dumps would likely occur. The ARD fate and transport analysis provided in the 1997 Draft EIS, Appendix J indicated that full chemical neutralization of ARD would occur within 2,200 to 4,400 feet downgradient of the toe of the dump, within the GSM's mixing zone. Thus, no impacts were predicted to groundwater outside the GSM permit boundary, or to the Jefferson River alluvial aquifer.

For this SEIS analysis, Telesto (2003c) evaluated data from West Waste Rock Dump Complex lysimeters, the 2002 to 2003 pit sump, highwall test pads, and springs and seeps. Because the pit would be backfilled with waste rock, chemistry of porewater from the West Waste Rock Dump Complex was deemed to be most representative.

Concentrations of constituents in the pit sump water are comparable, if not slightly more concentrated, than the West Waste Rock Dump Complex pore waters.

The 1997 Draft EIS, Appendix J stated that uncertainties regarding the model inputs and the simulation itself allow for only a low to moderate level of confidence in the model predictions of specific ARD concentrations and travel times to various locations down gradient of the waste rock dumps. This limitation also holds for the updated evaluation presented in this SEIS.

The results of the updated long-term fate and transport evaluation of the East Waste Rock Dump Complex led to the following conclusions:

- Combining updated middle to worst case hydrogeologic parameters in the fate and transport equations, and in the absence of any attenuation, the total time of travel from the top of the East Waste Rock Dump Complex to the Jefferson River alluvial aquifer via the Bozeman Group aquifer was shortened from a range of 960 to 1,300 years in the 1997 Draft EIS, to 245 to 575 years;
- This SEIS analysis indicates that 1 to 3 gpm of the East Waste Rock Dump Complex discharge would enter the Tdf/colluvial aquifer in Rattlesnake Gulch. Using updated information and combining the worst case hydrogeologic parameters in the fate and transport equations, and in the absence of any attenuation, the timeframe to breakthrough from the top of the East Waste Rock Dump Complex to the Jefferson River alluvial aquifer via the Tdf/colluvial aquifer in Rattlesnake Gulch is estimated to be 80 and 250 years for non-attenuated and attenuated contaminants respectively (HSI, 2003);
- The attenuation analysis in the 1997 Draft EIS, Figure 5-1 in Appendix B, which predicted that no ARD contaminants would move beyond 2,200 to 4,400 feet down gradient of the East Waste Rock Dump Complex, was checked with a straight pore-volume attenuation analysis based on the ARD Attenuation Study (Schafer and Associates, 1994). This approach indicates that 1.4 pore volumes of attenuation could be expected along the East Waste Rock Dump Complex flow path, and that ARD breakthrough beyond the permit boundary could occur in the range of 280 to 700 years. Groundwater capture would be required to prevent migration beyond the permit boundary; and,
- Mitigation measures, including additional groundwater monitoring, capture and treatment at the East Waste Rock Dump Complex, were approved in the 1998 ROD and incorporated into the permitted mixing zone for the East Waste Rock Dump Complex. Mitigation Measure W-4, Stipulation 010-7 in the 1998 ROD, responded to the issue of potential ARD releases that are premature or have greater than expected flows. This measure requires monitoring of groundwater at the mixing zone boundary and establishment of additional capture wells as a contingency under the GSM operating permit.
- The volume of seepage from the East Waste Rock Dump Complex predicted in this SEIS is within the contingency volume identified in the 1997 Draft EIS for the water treatment plant.

4.3.2.1.2.2 Impacts from Pit Seepage

Table 4-5 compares the projected pit water quality for this SEIS and the 1997 Draft EIS to Montana Groundwater Quality Standards. Table 1 of Appendix A of the 1997 Draft EIS presented estimated groundwater quality in the backfilled pit. Water quality was based on an average of values from the Ohio Adit, Stage 2 pit sump, Stage 3 pit sump, highwall seepage, and water treatment plant feed water.

The No Pit Pond Alternative would provide complete control of pit discharges by maintaining the pit water level as close as possible to the 4,525-foot elevation. There would be no risk of violation of groundwater standards and beneficial uses in the Jefferson River alluvial aquifer.

4.3.2.2 Impacts to Surface Water Quality and Quantity

4.3.2.2.1 Impacts to Springs, Wetlands

4.3.2.2.1.1 Impact from Waste Rock Dump Seepage

As discussed in Section 4.3.1.1, no impacts to surface water quality and quantity from the portion of the East Waste Rock Dump Complex in Rattlesnake Gulch are anticipated during active mining operations through Stage 5B. Rattlesnake Spring is already affected by naturally acidic groundwater. This SEIS analysis found that 13 percent of the East Waste Rock Dump Complex could contribute 1 to 3 gpm of ARD to Rattlesnake Gulch, which could affect water quality and quantity in the spring, possibly impacting its use for wildlife in the future. Mitigation of impacts to wildlife use of springs is required by Measure W-1, which was approved in the 1998 ROD as Stipulation 010-4.

Table 4 - 5 Projected Pit Backfill Water Quality
(all in mg/L except pH, s.u.)
Bolded numbers exceed the WQB-7 standards

Constituent	SEIS Project Pit Backfill Chemistry Porewater Quality[1, 4]	1997 Draft EIS Pit Water Quality[2]	Montana Groundwater Quality Standards[3]
pH	2.23[5]	2.7	--
TDS	--	15,698	--
Calcium (Ca)	412	408	--
Magnesium (Mg)	530	1,199	--
Sodium (Na)	82	59	--
Potassium (K)	6	15	--
Sulfate (SO_4)	22,400	10,240	--
Nitrate+Nitrite as N (NO_3 + NO_2-N)	--	10.9	--
Aluminum (Al)	1,410	292	--
Arsenic (As)	**0.056**	**0.411**	.02
Cadmium (Cd)	**0.138**	**0.641**	.005
Chromium (Cr)	0.988	0.009	.1
Copper (Cu)	**55.88**	**75.9**	1.3
Iron (Fe)	**508**	**1,170**	.3
Lead (Pb)	0.01	**0.274**	.015
Manganese (Mn)	**37.78**	**126**	.05
Mercury (Hg)	0.001	0.000	.002
Nickel (Ni)	**13.03**	**5.84**	.1
Selenium (Se)	**0.0563**	0.015	.05
Silver (Ag)	--	0.000	.1
Zinc (Zn)	**21.33**	**90.4**	2

[1] *Concentrations are representative of the 75th percentile of the West Waste Rock Dump Complex pore water from Shafer Limited, 2001.*

[2] *1997 Draft EIS, Appendix A, Table 1*

[3] *WQB-7, January 2004 (note that iron and manganese have only secondary standards)*

[4] *SEIS data from Telesto, 2003c*

[5] *Concentrations are representative of the 25th percentile of the West Waste Rock Dump Complex pore water from Shafer Limited, 2001.*

4.3.2.2.1.2 Impacts from Pit Seepage

Impacts to springs outside the pit could be expected due to dewatering. This is similar to the conclusion reached in the 1997 Draft EIS, Chapter IV, Section IV.B.6.b. Stepan Spring has the greatest potential for reduced flows resulting from active pit dewatering. The Stepan Original Spring has less potential for reduced flows than Stepan Spring, but is more likely to have reduced flow than Rattlesnake Spring and Bunkhouse Springs. Rattlesnake Spring and Bunkhouse Springs have a potential for reduced flow, but any reduction in flow is expected to be minimal since no impact has been seen from pit dewatering to date and these springs occur in the T/Q alluvial aquifer.

As stated in the 1997 Draft EIS, Chapter IV, Section IV.B.6, accurate quantification of incremental changes in spring discharge is not possible. It is anticipated that change in groundwater levels and impacts to spring flow would be somewhat greater under the No Pit Pond Alternative in this SEIS than the No Pit Pond Alternative in the 1997 Draft EIS due to the groundwater level being reduced from 4,700 to 4,525-foot elevation. Long-term potential to reduce spring flows would be as predicted in the 1997 Draft EIS. Mitigation of long-term impacts to downgradient springs requires a monitoring and spring enhancement plan. GSM maintains a spring monitoring program, including flow rates and water quality (GSM, 2002a), as required by Measure W-1 approved as Stipulation 010-4 in the 1998 ROD. This mitigation measure is adequate for the No Pit Pond Alternative.

The hydrograph analysis indicated that the groundwater cone of depression around the pit may not have reached equilibrium with the pit dewatering (HSI, 2003). The cone of depression can be expected to increase until equilibrium is achieved. This could take tens of years (HSI, 2003). Associated long-term impacts to springs could be somewhat greater than the operational impacts, as described in Section 4.3.1.2.1.

4.3.2.2.2 Risk of Violation of Surface Water Standards and Impacts to Beneficial Uses of the Jefferson River and Slough

The Montana Water Quality Act defines impacts to beneficial uses as impacts to public water supplies, wildlife, fish and aquatic life, agriculture, industry, livestock, and recreation. Known beneficial uses in the vicinity of GSM are shown on Map IV-2 of the 1997 Draft EIS, Chapter IV, Section IV.B. A review of beneficial uses relative to this SEIS evaluation follows.

4.3.2.2.2.1 Impacts from Waste Rock Dump Seepage

There are no close public water sources down gradient of the East Waste Rock Dump Complex. Domestic wells are located approximately 4,000 feet down gradient from Tailings Impoundment No. 2. The nearest downgradient surface water fishery is the Jefferson Slough. An area of GSM's property along the Jefferson River Slough is leased for cattle grazing. Acreage adjacent to the Jefferson Slough is being cultivated.

There are no known industrial uses outside of the existing mine operations, or recreational beneficial use of the water resource that would be impacted by ARD from the waste rock dump complexes.

Because of limited surface water availability, springs at the mine site provide local wildlife habitat. The 1997 Draft EIS, Chapter III, Section III.B.2.d reported that Rattlesnake Spring, located approximately 3,100 feet down gradient of the East Waste Rock Dump Complex, was believed to receive flow from the Bozeman Group aquifer, potentially, in part from the abandoned Rattlesnake adit (Lazuk, 1996). At the surface, Rattlesnake Spring emerges from Tdf/colluvial aquifer (GSM, 1993; Golder,1995a). Bunkhouse Springs is approximately 3,400 feet down gradient of the East Waste Rock Dump Complex and occurs within the Tdf/colluvial aquifer.

The 1997 Draft EIS, Chapter IV, Section IV.E.1.a stated that because these springs are used by wildlife for watering, impacts to wildlife associated with reduced water quality could occur, and that impacts are less likely to occur in Rattlesnake Spring, because of the ARD attenuation effects that are anticipated in the Bozeman Group aquifer. As discussed in Section 3.3.4 of this SEIS, the gravel deposits from which both of these springs discharge are extensively altered by ferricrete deposits indicative of historic metal-rich groundwater transport and deposition of oxidation byproducts from sulfide mineralized zones in Bull Mountain. Rattlesnake Spring and Bunkhouse Springs have been acidic, with pH typically 4 to 5, and elevated metals concentrations for the monitoring record, going back to 1993 for Rattlesnake Spring. As indicated in Section 3.3.4, these springs have been affected by groundwater from naturally mineralized deposits.

This SEIS analysis found that the primary groundwater flow path from the East Waste Rock Dump Complex is through the Bozeman Group aquifer east of these springs (HSI, 2003). One to three gpm of seepage from 13 percent of the East Waste Rock Dump Complex could find its way into the Rattlesnake Gulch drainage and potentially impact Rattlesnake Spring. This could lead to further decline in pH and increases in metal concentrations. Impacts to Bunkhouse Springs would not be expected due to its location west of Rattlesnake Gulch.

In summary, the only beneficial use expected to be impacted by ARD migration down gradient of the 13 percent of the East Waste Rock Dump Complex in Rattlesnake Gulch, within the limits of the permitted mixing zone, is Rattlesnake Spring, which is used by wildlife. The spring has been acidic since monitoring began due to prehistoric deposition of oxidation byproducts within the aquifer, and any additional impacts to the Rattlesnake Spring may not be attenuated. Adverse impacts to other beneficial uses are not anticipated for the No Pit Pond Alternative. Mitigation of impacts to beneficial uses, namely, springs used by wildlife, within the mixing zone boundaries was required by Measure W-1, which was approved as Stipulation 010-4 in the 1998 ROD, that requires monitoring for changes in spring water quantity and quality.

The 1997 Draft EIS, Chapter IV, Section IV.B.1.a concluded that there would be no risk of violation of water quality standards and impacts to beneficial uses of the Jefferson River and Slough from ARD from the East Waste Rock Dump Complex under the No Pit Pond Alternative. This SEIS analysis supports that conclusion,

4.3.2.2.2.2 Impacts from Pit Seepage

Under the No Pit Pond Alternative through Stage 5B, water inflows to the pit are expected to be similar to present conditions averaging 32 gpm (Telesto, 2003a). Groundwater inflows to the pit are not expected to increase even though the pit would be deepened from the 4,650-foot to the 4,525-foot elevation during Stage 5B. Monitoring over the past 5 years has shown that pit inflows have not been increasing as the pit was deepened. The volume of water intercepted by the underground mine, which is 300 feet beneath the current bottom of the pit, was typically less than 5 gpm, based on visual observation.

The agencies have assumed that the No Pit Pond Alternative would provide complete control of pit discharges by maintaining the pit water level as close as possible to the 4,525-foot elevation. Therefore, there would be no risk of violation of groundwater standards and beneficial uses in the Jefferson River and Slough.

4.3.2.3 Reclamation Plan Changes

The 1997 Draft EIS, Chapter IV, Section IV.C addressed the soil impacts that are common to all alternatives for the currently approved reclamation plan for the areas in the pit to be revegetated. The current approved plan includes covering major benches that have sufficient width to allow machinery access with 2 feet of pH neutral, oxide, non-acid producing waste rock plus 2 feet of stockpiled soil for a total of 4 feet of growth medium (1997 Draft EIS, Chapter II, Section II.B).

GSM reclaimed the South Waste Rock Dump in 1998-2000 following the approved reclamation plan. The stockpiled oxide waste rock turned out to be slightly acid producing and had to be amended with lime. After the reclamation was completed, the agencies and GSM concluded that it would be better to come up with alternate materials if possible rather than amend the waste rock with lime.

In the fall of 1999, GSM started reclaiming the West Waste Rock Dump Complex. Evaluations of the stockpiled oxide waste rock that was to be used identified that these materials were slightly acid producing.

As a result, GSM investigated alternative materials and proposed a modification of the approved waste rock dump reclamation coversoil system on August 22, 2000 (GSM, 2000). The proposed change was to place 3 feet of non-acid producing stockpiled soil over the acid producing sulfide waste rock rather than the currently approved coversoil system. The agencies evaluated the proposal and approved the change based on characteristics of the west side soils (DEQ and BLM, 2001).

The agencies did not approve the change for the East Waste Rock Dump Complex without further characterization of the east side soil stockpiles (DEQ and BLM, 2001a). GSM did further studies in 2001 and applied to modify the approved reclamation coversoil system for the East Waste Rock Dump Complex and the pit acres to be revegetated (GSM, 2001). GSM reapplied to place 3 feet of non-acid producing stockpiled soil over the acid producing sulfide waste rock rather than the approved 48-inch coversoil system. The agencies evaluated the proposal and approved the change (DEQ and BLM, 2002, 2003). For 2H:1V slopes, the agencies required that the east side soils be amended with rock to raise the coarse fragment content to greater than 45 percent.

The agencies did not approve the change for the pit areas to be revegetated because of a shortfall of soils stockpiled on the east side and the amount of 2H:1V slopes that would be revegetated in a partial pit backfill alternative (DEQ and BLM, 2003). The changes in the coversoil system for the pit acres to be revegetated are evaluated in this SEIS.

The potential reclamation plan changes that would occur from the 1997 Draft EIS are as follows:

- Volumes of soil needed for reclamation capping;
- Composition and thickness of layers of soil cover;
- Amount of surface disturbance;
- Hazards to wildlife; and,
- Amount of unrevegetated acres.

Table 4-6 summarizes the volume of soil needed for pit reclamation in the alternatives. As of December 31, 2003, there were 2,234 total acres of disturbance within the GSM permit boundary (Table 2-1). Of that total, 1,054 acres have been reclaimed to date (GSM 2003 Annual Report). The reclamation of all other associated disturbance (tailings ponds, facilities, roads, etc.) is not shown in Table 4-6. The associated disturbance around the pit was addressed under the 1997 Draft EIS and is common to all pit reclamation alternatives under consideration.

Table 4 - 6 Soils Comparison by Alternative for Immediate Pit Reclamation

Reclamation Plan	Additional New Pit Disturbance/ Pit Soil Cover Area (Acres)	Cover Soil Source	Cover Soil Required for Pit Closure Area (Cubic Yards)	Pit Acres Left Unrevegetated
No Pit Pond Alternative	0 / 53	Stockpiles	290,400	158
Partial Pit Backfill With In-Pit Collection Alternative	56/ 292[1]	Stockpiles plus soil borrow area	1,541,800	0
Partial Pit Backfill With Downgradient Collection Alternative	58 / 292[1]	Stockpiles plus soil borrow area	1,541,800	0
Underground Sump Alternative	0 / 52	Stockpiles	285,000	158

[1] Actual pit disturbance after reclamation would be 274 acres (218 plus 56 cast blasted). The 292 acres listed in the table under the partial pit backfill alternatives represent the total acres that need to be soiled and revegetated on 2H:1V slopes. The 2H:1V slopes increase the total acres by 18.

GSM has proposed a coversoil system consisting of 3 feet of soil for the pit acres to be revegetated in all alternatives. On 2H:1V slopes, the soil would be amended with rock to raise the coarse fragment content to more than 45 percent as is approved for the East Waste Rock Dump Complex (GSM, 2002a).

The 3 feet of coversoil would be amended. On 2H:1V slopes in the pit, GSM would either use borrow soil meeting the rock fragment requirement or blend coversoil with more rocky potentially acidic waste rock to increase the rock content from 30 percent to greater than 45 percent. The waste rock would have a net acid generating pH value greater than 4.5 to meet quality criteria approved for the East Waste Rock Dump Complex in Minor Revision 01-004 (DEQ and BLM, 2002 and 2003). A sample frequency of one sample per 10,000 tons would be used for soil testing to determine acid producing potential. GSM estimates that approximately 15 percent of the stockpiled waste rock would be used to raise the rock content of the calcareous coversoil to greater than 45 percent. Non-acid generating cover soil may be available from borrow areas.

GSM would test mixtures of the calcareous soils and the potential acidic waste rock materials to develop a recipe to produce the more than 45 percent rock content needed in the surface soils on 2H:1V slopes. GSM would verify that the resultant mixture would have a net neutralizing potential at a 3:1 ratio above the acid generating potential. After placement GSM would verify net neutralizing potential again by sampling a 100 by 100-

foot grid on the final surface. Verification of no impacts to plant growth with this plan would be addressed by a relevant third party technical specialist.

GSM would amend the surface soils with agency-approved organic amendments. GSM would try to achieve an average 1.0 percent organic matter content in the upper 4 inches of the replaced coversoils after organic matter addition. GSM would sample the organic matter content on a 100 by 100-foot grid on the regraded coversoil slopes. GSM has to document that the proper application rate has been calculated, applied, and incorporated as best as possible. GSM is concerned that because of the 2H:1V slope, the organic matter would not be incorporated completely. Some would be lost to wind and water erosion. The agencies believe that some loss is acceptable. Any organic matter would enhance the establishment of microbes in the soil.

The 3-foot coversoil is intended to minimize infiltration into the waste rock by storing water within the cover material during wet periods and allowing water to be removed by evapotranspiration from the cover during drier periods. Cover thickness over about 18 inches in this climate would result in negligible increases in infiltration rate (Prodgers, 2000). The amount of water infiltrating through either cover type would be similar and within the range used for water balance estimations (i.e., 0.25 to 0.5 inch/year, or 2 to 4 percent of average annual precipitation) (Telesto, 2003a).

While the net infiltration through both covers is estimated to be similar, the durability of the covers may be different. Based on the experience with cover placement and maintenance on the West Waste Rock Dump Complex, it is anticipated that the 3-foot soil cover with more than 45 percent coarse fragments would adequately resist erosion, particularly on slopes (DEQ and BLM, 2001a, 2003). This design has been approved for the East Waste Rock Dump Complex.

GSM has provided soil analyses for the proposed borrow site north of Tailings Impoundment No. 2 (GSM, 2002a). The agencies would require further testing to verify that the rock size and characteristics are adequate for use on 2H:1V slopes. An amendment to add rock fragments would be required if necessary. The agencies have concluded that the 3-foot coversoil system with the required rock content and characteristics approved for 2H:1V slopes on the waste rock dump complexes would be adequate to revegetate waste rock backfilled into the pit under any of the alternatives.

4.3.2.3.1 Surface Disturbance

GSM's permit area is 6,125 acres. GSM was permitted for 2,964 acres of disturbance (1997 Draft EIS, Table II-22) (GSM 2003 annual report). GSM's currently approved area for disturbance is 3,002.25 acres. GSM is currently bonded for 2,619.55 acres of disturbance.

Table 2-1 compares the permitted disturbances at GSM with the proposed disturbances at the end of Stage 5B mining. GSM's current actual disturbance is 2,234 acres. The numbers reported in Table 2-1 do not match the 1997 Draft EIS, Table II-22 because of updated mapping (GSM 2003 annual report). GSM has completed 1,054 acres of reclamation within the disturbance boundary. Table 2-1 details the completed reclamation.

The 1997 Draft EIS, Table II-22 estimated the pit disturbance area would be 254 acres. GSM's reclamation bond included covering with the 4-foot coversoil system and revegetation of 26 acres of pit area. The total pit disturbance area was permitted to be 336 acres of which 108 acres would be revegetated.

This SEIS estimates the pit disturbance area would be 218 acres. GSM proposes a 3-foot cover soil system and revegetation of 60 acres of the pit area. The total pit disturbance area would be 286 acres of which 128 acres would be revegetated. Seven acres in the pit area have been reclaimed with a 4-foot coversoil system. Under the No Pit Pond Alternative, GSM would revegetate another 53 acres (7 acres already reclaimed) with the 3-foot coversoil system, requiring 290,400 cubic yards of soil. None of the total 60 acres to be reclaimed would be on 2H:1V slopes and would not require rock amendments. Some soil placed inside the pit below the highwall is at risk of being lost or possibly mixed with acidic highwall rock as the pit highwall gradually sloughs to more stable configurations. The amount of soil that would be lost would be minimal. The soil loss would be an unavoidable impact of revegetating areas next to the highwall. GSM has enough soil stockpiled to reclaim the pit acres.

4.3.2.3.2 Hazards to Wildlife

A total of 2,234 acres is currently disturbed, and Stage 5B mining is not expected to result in additional disturbance (GSM, 2002a). No additional pit area disturbance would be created under this alternative. The pit would only be backfilled with 111,000 cubic yards (167,000 tons) of waste rock. This would leave almost 1,775 feet of acid-producing highwall exposed. Because there would be no further pit surface disturbance, there would be no additional hazards to wildlife beyond those analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.e. If the pit cannot be dewatered for some reason and a lake forms in the pit, an additional hazard to wildlife would develop from exposure to contaminated water.

4.3.2.3.3 Total Remaining Unrevegetated Acres

In the 1997 Draft EIS, based on Chapter II, Section II.B.6.b and Table II-14, 228 out of 254 acres in the pit would be left unrevegetated. In this SEIS, of the 218 pit acres, 158 acres would be left unrevegetated. The difference is due to the reconfiguration of the pit since 1998.

4.3.3 Partial Pit Backfill With In-Pit Collection Alternative

(Proposed Action)

4.3.3.1 Impacts to Groundwater Quality and Quantity

4.3.3.1.1 Risk of Impacts to Groundwater Quality and Quantity in Permit Area

4.3.3.1.1.1 Impacts from Waste Rock Dump Seepage

In the 1997 Draft EIS, Chapter II, Section II.B.7.b, 34,700,000 to 36,700,000 cubic yards (52,000,000 to 55,000,000 tons), or 30 to 32 percent of the total East Waste Rock Dump Complex volume would have been removed for backfill under the Partial Backfill Alternative. Approximately 20,500,000 to 22,000,000 cubic yards (30,800,000 to 33,000,000 tons) or 15 to 16 percent of the West Waste Rock Dump Complex would have been removed to cover the upper highwall. The West Waste Rock Dump Complex footprint would not have been reduced. In the 1997 Draft EIS, Chapter IV, Section IV.B.7, the East Waste Rock Dump Complex footprint would have been reduced by 82 acres.

In this SEIS, the partial pit backfill alternatives would remove 33,300,000 cubic yards (50,000,000 tons) or 33 percent of the total East Waste Rock Dump Complex volume at the end of Stage 5B. The footprint area would remain the same (GSM, 2002a), so the spatial dimension of potential impacts from the East Waste Rock Dump Complex would remain similar (Figure 2-6). To cover the upper highwall, 11,900,000 cubic yards (17,900,000 tons) of pit highwall material would be cast blasted to create the 2H:1V slopes. No West Waste Rock Dump Complex waste rock would be removed for backfill.

The topography of the East Waste Rock Dump Complex after mining Stage 5B is shown in plan and cross-section views on Figure 2-5, and the final configuration of the East Waste Rock Dump Complex after removing material for backfilling is shown on Figure 2-6.

Waste rock water quality would not change under the Partial Pit Backfill With In-Pit Collection Alternative. Impacts to long-term water quality under this alternative would be similar to those of the No Pit Pond Alternative, except that the East Waste Rock Dump Complex would achieve a saturated condition sooner, since the maximum thickness of waste rock would be reduced from 300 feet to 200 feet (Figure 2-5). Overall, the potential ARD impacts from the East Waste Rock Dump Complex under this alternative would be the same as under the No Pit Pond Alternative.

Since the thickness of the East Waste Rock Dump Complex would be reduced from approximately 300 feet to 200 feet in the thickest area, the time it would take for the remaining waste rock to become wet to the point ARD exits the dump would be less.

There would be less geochemical uptake of water, and the drying effect of convective air movement that occurs in waste rock dumps would be diminished. The average time until seepage begins would reduce from a range of 50 to 200 years (1997 Draft EIS, Chapter IV, Section IV.B.1.a), to 11 to 24 years (HSI, 2003: Table 6-2). This is based on a 100-foot thickness of waste rock. The downward migration of the 1 to 3 gpm seepage from the base of the East Waste Rock Dump Complex down the Rattlesnake Gulch drainage would be similar to that described for the No Pit Pond Alternative.

4.3.3.1.1.1.1 Long-Term Monitoring and Mitigation for Unanticipated East Waste Rock Dump Complex Seepage

Impacts to, and mitigation measures for, groundwater resources and beneficial uses of water would be the same as for the No Pit Pond Alternative.

4.3.3.1.1.1.2 Summary of East Waste Rock Dump Complex Impacts to Water Quality and Water Quantity

No impacts to groundwater quality from the portion of the East Waste Rock Dump Complex in Rattlesnake Gulch are anticipated during active mining operations through Stage 5B. An updated evaluation in this SEIS of the 1997 Draft EIS modeling using combinations of middle to worst-case parameters predicts that groundwater below the East Waste Rock Dump Complex would first experience ARD impacts in 33 to 87 years rather than in 844 to 1,223 years as predicted in the 1997 Draft EIS, but to a similar degree. The water treatment plant has been designed to handle 25 gpm of seepage from the East Waste Rock Dump Complex as a contingency (1997 Draft EIS, Appendix A, Table 2-1).

4.3.3.1.1.2 Impacts from Pit Seepage

4.3.3.1.1.2.1 Impacts to Water Quality

Under the Partial Pit Backfill With In-Pit Collection Alternative, the pit would be backfilled from 4,525 feet to an average elevation of 5,400 feet. The pit highwall would be reduced to 2H:1V slopes by cast blasting and dozing. The backfilled pit would be graded at 4.3 percent to create a free-draining surface, and a 3-foot soil cover would be placed over the entire backfilled pit and reduced highwall and revegetated. Four wells would be installed through the backfill to the bedrock contact to maintain the pit as a hydrologic sink. As under the No Pit Pond Alternative, pit dewatering coupled with water treatment would be required.

The principal objective of this alternative would be similar to the No Pit Pond Alternative and would be to maintain the pit as a hydrologic sink and keep the groundwater level as close as possible to the pit bottom elevation of 4,525 feet. If successful, this would control the ARD produced by the pit at its source and eliminate the risk of water quality impacts from pit groundwater seepage outside the pit.

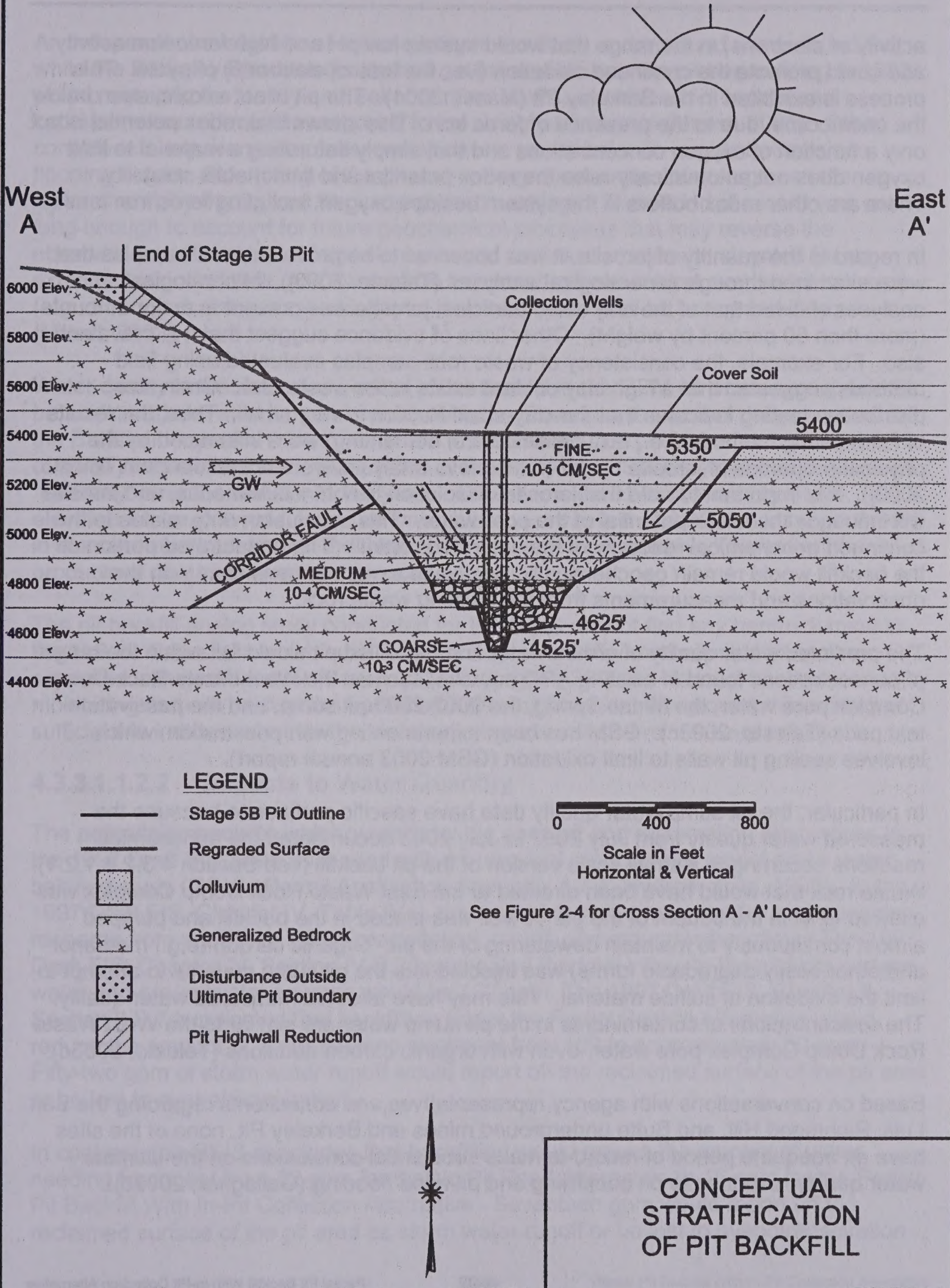
The first 100 feet of backfill would be the same as for the No Pit Pond Alternative. Above this, approximately 33,200,000 cubic yards (50,000,000 tons) of waste rock from the East Waste Rock Dump Complex would be backfilled to an average 5,400-foot elevation. Cast-blasting and dozing would create the 2H:1V final highwall slope. Slope breaks and surface water diversions off the slopes and backfill area are described in Section 2.4.3.5. Figure 4-1 shows the potential stratification of the pit backfill after pit backfilling. The final pit configuration after backfilling the pit is shown in Figure 2-4 in both a plan view and cross-sectional view.

In the 1997 Draft EIS, Appendix A, Table 1, groundwater quality in the backfilled pit was assumed to be an average of the Ohio Adit, Stage 2 pit sump, Stage 3 pit sump, highwall seepage, and water treatment plant feed water. A reevaluation of the projected chemistry of pit water in the Partial Pit Backfill With In-Pit Collection Alternative was performed (Table 4-5) (Telesto, 2003c). If successful, dewatering would maintain the groundwater level in the backfill as close as possible to the 4,525-foot pit bottom elevation. The majority of the backfill would remain above the saturated zone, and geochemical reactions characteristic of an unsaturated environment would predominate. Oxidation of sulfide minerals in the unsaturated zone in the backfilled pit would proceed as in the reclaimed waste rock dump complexes, and the water chemistry would be similar to the pore water chemistry observed in the West Waste Rock Dump Complex (Table 4-5) (Telesto, 2003c). The poor water quality would be expected to occur for hundreds to thousands of years.

Table 4-5 lists the estimated quality of pit water under the Partial Pit Backfill With In-Pit Collection Alternative, which corresponds to West Waste Rock Dump Complex pore waters (Telesto, 2003c). Because the geochemical processes in an unsaturated backfill scenario would be similar to those in the existing waste rock dumps, the water quality from the unsaturated pit backfill would be the same as in the waste rock dumps. The agencies have assumed that this water quality would develop in any waste rock used for backfill. Table 4-5 lists the water quality used in the 1997 Draft EIS and Montana groundwater quality standards for comparison.

The concentrations listed in Table 4-5 are intended as indicators of probable backfill water quality, and the values listed are not intended to represent a chemically balanced water. The potential exists that some constituents could be slightly higher and others slightly lower than indicated. Placement of the waste rock material in the backfilled pit would result in low-pH, elevated metal-bearing groundwater from initiation of groundwater contact with the backfill for hundreds to thousands of years (Telesto, 2003c).

Jarosite is a byproduct of sulfide oxidation and can be characterized as a ferric-hydroxide sulfate mineral. In the unsaturated zone of the backfill, jarosite would be expected to continue to form because the geochemical processes in the unsaturated backfill would be no different than those in the waste rock dumps. In the saturated zone, assuming that oxygen flux is limited, jarosite would likely start to dissolve (Telesto, 2003c). As long as it is present, it would keep the redox potential (i.e., the


West
A
East
A'
End of Stage 5B Pit
Collection Wells
Cover Soil
6000 Elev.
5800 Elev.
5600 Elev.
5400 Elev.
5200 Elev.
5000 Elev.
4800 Elev.
4600 Elev.
4400 Elev.
5400'
5350'
5050'
4625'
4525'
FINE
10^{-5} CM/SEC
GW
CORRIDOR FAULT
MEDIUM
10^{-4} CM/SEC
COARSE
10^{-3} CM/SEC
LEGEND
Stage 5B Pit Outline
Regraded Surface
Colluvium
Generalized Bedrock
Disturbance Outside Ultimate Pit Boundary
Pit Highwall Reduction
0
400
800
Scale in Feet
Horizontal & Vertical

See Figure 2-4 for Cross Section A - A' Location

CONCEPTUAL STRATIFICATION OF PIT BACKFILL

Figure 4-1.dwg

(Telesto - Feasibility Assessment, 2003e)

FIGURE 4-1

activity of electrons) in the range that would sustain low pH and high ferric iron activity and could promote the continued oxidation (i.e., the loss of electrons) of pyrite. This process is exhibited in the Berkeley Pit (Maest, 2004). The pit is not anoxic, even below the chemocline, due to the presence of ferric iron. This shows that redox potential is not only a function of oxygen concentrations and that simply saturating a material to limit oxygen does not automatically raise the redox potential and limit metals solubility. There are other redox buffers in the system besides oxygen, including ferric iron ions.

In regard to the quantity of jarosite, it was observed to be prevalent in all samples that were examined through mineralogical analyses (Telesto, 2003j). Mineralogical analyses showed that of the clay sized particles, jarosite was present in major amounts (more than 50 percent by weight). Other lines of evidence suggest that it is prevalent also. For example, the consistency of waste rock samples evaluated using field methods suggested that a high clay content exists in the waste rock. Grain size distribution testing indicates that the clay-sized fraction is very small. Thus, the results of field-testing methods (i.e., texture, amount of cementing) were influenced by the physical properties of jarosite by which the sieve analyses were not influenced (Telesto, 2003j). It is important to note that jarosite dissolution is not instantaneous, and jarosite will influence the redox potential of the pore water. This conclusion only relates to the continued geochemical reactivity of the saturated backfill. The unsaturated portion of the backfill would remain geochemically reactive in a manner consistent with the observations and measurements from the existing waste rock.

The predicted water quality of groundwater in a backfilled pit would fall within the range of concentrations found in existing ARD sources, such as the West Waste Rock Dump Complex pore water, the Midas Spring, the 2002-2003 pit sump, and the passivation test pads (Telesto, 2003c). GSM has been experimenting with passivation, which involves sealing pit walls to limit oxidation (GSM 2003 annual report).

In particular, the pit sump water quality data have specific pertinence because the measured water quality from July 2002 to July 2003 documented the geochemical reactions occurring in a small scale version of the pit backfill (see Section 4.3.2.1.1.2.1). Waste rock that would have been directed to the East Waste Rock Dump Complex was allowed to fill in the bottom of the pit. A well was placed in the backfill and pumped almost continuously to maintain dewatering of the pit. Organic carbon (e.g., methanol and other easily degradable forms) was injected into the pit sump material to attempt to limit the oxidation of sulfide material. This may have affected measured water quality. The concentrations of contaminants in the pit sump water are similar to the West Waste Rock Dump Complex pore water, even with organic carbon additions (Telesto, 2003c).

Based on conversations with agency representatives and consultants regarding the San Luis, Richmond Hill, and Butte underground mines and Berkeley Pit, none of the sites have an adequate period of record to make substantial conclusions on the ultimate water quality response to pit backfilling and pit/mine flooding (Gallagher, 2003c).

An independent evaluation of water quality in the Butte underground mines found that while the Berkeley Pit water quality has not improved since the pit began filling in 1982, pH increased in the Kelley and Belmont mine shafts, and dissolved copper and cadmium were reduced, in response to the rising water levels (Maest, 2003). Other constituents experienced smaller reductions or no reduction in concentration since flooding began. Monitoring of the pit and underground water noted large variation in water chemistry throughout the underground workings. The period of record was not long enough to account for future geochemical processes that may reverse the observed improvements. Major elements and metals could remain elevated for an extended period of time, and it would be important to have control over water in the pit (e.g., through draining via workings) so that treatment could be performed if required (Maest, 2003).

Water quality in the saturated portion of the backfill in the GSM pit would be expected to be acidic and elevated in metal concentrations. Based on the limited data reviewed in the Butte underground mines, which are not backfilled, it is possible that concentrations of some metals in the saturated portion of the backfilled GSM pit water would decrease "naturally" over the first five to ten years. Other metals and sulfate could remain elevated for an extended period of time. It is conceivable that ARD would be generated in the saturated backfill until the sulfides have reacted completely. Thereafter, the products of oxidation would be reduced and mobilized.

The pit backfill analog study conducted for this SEIS did not find any hardrock mine in the U.S. or Canada in which such a large pit was backfilled and allowed to become saturated with groundwater (Kuzel, 2003; Gallagher, 2003c). No long-term water quality monitoring records exist at the backfilled mines or flooded underground mines studied sufficient to indicate whether the reclamation goals at those mines were achieved.

4.3.3.1.1.2.2 Impacts to Water Quantity

The potential impacts to water quantity by the open pit and reclamation alternatives in the 1997 Draft EIS, were evaluated with a numerical groundwater model and a water balance study (GSM's Permit Application Appendix 4.7-1, Hydrometrics, 1995). In the 1997 Draft EIS, Chapter IV, Table IV-5, the water balance accounted for surface water recharge from snowmelt, direct precipitation, runoff, and groundwater inflow. The 1997 Draft EIS, Chapter IV, Section IV.B.2.b estimated the total inflow to the pit from surface water and groundwater sources would be 102 gpm. The 1997 Draft EIS, Chapter II, Section II.B.7.b indicated that backfilling under the Partial Backfill Alternative would reduce the amount of water needing treatment from 102 to approximately 50 gpm. Fifty-two gpm of storm water runoff would report off the reclaimed surface of the pit area or be lost to evapotranspiration.

In contrast, this SEIS concludes that backfilling would reduce the amount of water needing treatment from 32 gpm for the No Pit Pond Alternative to 15 gpm for the Partial Pit Backfill With In-Pit Collection Alternative. Seventeen gpm would report off the reclaimed surface of the pit area as storm water runoff or be lost to evapotranspiration

(Telesto, 2003a). The ratio of water pumped for treatment compared to that which runs off is about the same as in the 1997 Draft EIS, with the difference in values between these studies attributable to the updated water balance calculations performed for this SEIS (Telesto, 2003a). Although the revised rates of pit inflows are less, backfilling would not eliminate the need for the water treatment system.

The water balance for this SEIS was based on the past 5 years of pit water inflows and outflows. Average annual precipitation during that period has been reduced due to drought. The amount of water needing treatment could be somewhat higher in the future. The agencies assume that the total amount from the pit needing treatment would not exceed the 50 gpm indicated in the 1997 Draft EIS.

Cast blasting would increase pit disturbance by 56 acres to reduce the slope to 2H:1V. This could increase the amount of water infiltrating into the upgradient groundwater system, which would enter the Corridor Fault. This new disturbance would be covered with a 3-foot soil cover and revegetated. The agencies assume this would minimize infiltration, potentially balancing the increased water produced by 56 acres of new disturbance that could report to the pit.

4.3.3.1.1.2.3 Migration of Perched Groundwater

The potential for perched water migration across the pit was not analyzed for the Partial Backfill Alternative in the 1997 Draft EIS. The potential development of perched groundwater conditions in a backfilled pit was investigated for this SEIS (Telesto, 2003e). The development of perched groundwater conditions with cross-pit migration hinges on whether a low permeability layer would exist from compaction or be created by oxidation byproducts below the level of the seepage. In the backfilled pit, the concern would be for the poor quality perched water to migrate into bedrock and avoid capture in the pit dewatering system.

Seeps have been identified in the highwall of the pit, and some are observed to flow continuously throughout the year, particularly those associated with the Corridor Fault (Gallagher, 2003b). If the pit is backfilled, these seeps would be buried, but would continue to flow, possibly creating perched water within the backfill materials and potential problems with localized small failures if they saturate the backfill and soil cover on the upper slopes.

The results of the analysis suggest that if the vertical hydraulic conductivity of the low permeability layer is greater than 1×10^{-5} cm/sec, the perched water body would not likely extend to the opposite pit highwall (Telesto, 2003e). Measurements of the permeability of the fine fraction of waste rock ranged from 2×10^{-4} to 2×10^{-3} cm/sec (Herasymuik, 1996). Initially, development of a perched aquifer that migrates out of the pit is not indicated.

Sulfide oxidation byproducts are colloidal in nature and effectively could seal pore space over time reducing permeability below seeps to 1×10^{-5} cm/sec or less (G. Furniss, DEQ, personal communication, 2004). As oxygenated water continues to emerge from the seeps and react with backfill, an impermeable layer of reaction products would spread outward across the backfill and would prevent the water from seeping downward in the backfill.

As noted in the pit backfill analog study completed for this SEIS, both the San Luis and Richmond Hill mines developed unexpected seepage of groundwater down gradient from the pits. This was unexpected at the Richmond Hill mine because the pit was above the water table, so the source of the seepage was probably perched water in the backfill. The specific source of the seepage is not known but is suspected to be related to the pit (Gallagher, 2003c). The seep is impacted by ARD and must be captured and treated.

Permeability of the backfill could decrease over time due to compaction and weathering, as described in Section 4.2.2.1.2.

4.3.3.1.1.2.4 Summary of Pit Impacts to Water Quality and Quantity

The Partial Pit Backfill With In-Pit Collection Alternative has the same goal as the No Pit Pond Alternative: to maintain the pit as a hydrologic sink and treat the groundwater in the permanent water treatment plant. If the Partial Pit Backfill With In-Pit Collection Alternative were to perform as intended over the long term, the impacts would be similar to the No Pit Pond Alternative.

4.3.3.1.2 Risk of Violation of Groundwater Standards at the Permit Boundary and Impacts to Beneficial Uses of the Jefferson River Alluvial Aquifer

4.3.3.1.2.1 Impacts from Waste Rock Dump Seepage

Impacts from the 1 to 3 gpm of seepage from the East Waste Rock Dump Complex in Rattlesnake Gulch would be the same as the No Pit Pond Alternative. The seepage would begin to migrate sooner because 33 percent of the volume and 100 feet of the maximum thickness of 300 feet of waste rock would be removed. According to Figures 2-5 and 2-6, only 7 percent of the volume of waste rock on the 13 percent of the East Waste Rock Dump Complex lying in Rattlesnake Gulch would be removed for pit backfill under the Partial Pit Backfill With In-Pit Collection Alternative, and the footprint would not change.

4.3.3.1.2.2 Impacts from Pit Seepage

As a consequence of long-term failure of the dewatering system under this alternative, water would rise above the 5,050-foot elevation and reach a steady state at 5,260 (Telesto, 2003a) and discharge from the pit as it would under the Partial Pit Backfill With Downgradient Collection Alternative (see Section 4.2.2.9.2). Fifteen gpm of pit seepage would reach groundwater and move down Rattlesnake Gulch toward the Jefferson River alluvial aquifer along with the 1 to 3 gpm of seepage from the East Waste Rock Dump Complex in Rattlesnake Gulch. The Rattlesnake Gulch interception wells and Tailings Impoundment No. 1 south pumpback system wells would have to be maintained to monitor and try to capture this flow.

The groundwater level would continue to be drawn down around the pit as under the No Pit Pond Alternative. This is an unavoidable impact of maintaining the pit as a hydrologic sink.

4.3.3.2 Impacts to Surface Water Quality and Quantity

4.3.3.2.1 Impacts to Springs, Wetlands

4.3.3.2.1.1 Impacts from Waste Rock Dump Seepage

Impacts from waste rock dump seepage would be the same as the No Pit Pond Alternative.

4.3.3.2.1.2 Impacts from Pit Seepage

The 1997 Draft EIS, Chapter IV, Section IV.B.7.b concluded that spring flows outside the pit area under the Partial Backfill Alternative would be reduced because the pit would be maintained as a hydrologic sink. Impacts to the flow of springs and wetlands from pit dewatering under the Partial Pit Backfill With In-Pit Collection Alternative would be the same as the No Pit Pond Alternative. Under both, pit water elevations would be maintained as low as possible between 4,525 and 4,625 feet in elevation. As indicated in Section 4.2.2.5.2, under the Partial Pit Backfill With In-Pit Collection Alternative, groundwater levels in the backfilled pit could rise if operation or maintenance problems developed because of dewatering system failures. This could be caused by problems with well casings and pumps from settlement and corrosion of pumps and screens. The agencies would bond for additional wells to be installed to ensure that the water level would not rise above the 5,050-foot elevation. If the water level can be kept close to the 4,525-foot elevation, the impacts would be similar to the No Pit Pond Alternative.

The 1997 Draft EIS, Chapter IV, Sections IV.B.1.b and IV.B.7.b did not predict that, under the Partial Backfill Alternative, there would be any impacts to the water quality of springs from pit discharge. With the backfilled pit maintained as a hydrologic sink under the Partial Pit Backfill With In-Pit Collection Alternative, there also would be no water quality impacts to springs. However, if operational and maintenance problems led to loss of hydrologic control of pit groundwater allowing water levels to rise above the 5,050-foot elevation, ARD-affected water from the pit could reach existing springs, or create new ones. In this case, mitigation measures, such as Measure W-1 approved in the 1998 ROD as Stipulation 010-4, would be required to monitor, treat or augment spring discharge. Measure W-1 was designed to respond to the identification and replacement of reduced discharge or reduced water quality at springs and seeps. It allows for establishment of a monitoring and sampling program frequent enough to detect spring responses to seasonal variations and pit dewatering. Mitigation includes improving collection and interception of spring waters, supplying replacement water, and enhancing water resources for wildlife and livestock. Measure W-1 would have to be modified to cover increased flows from springs under this alternative.

4.3.3.2.2 Risk of Violation of Surface Water Standards and Impacts to Beneficial Uses of the Jefferson River and Slough

4.3.3.2.2.1 Impacts from Waste Rock Dump Seepage

Impacts from the 1 to 3 gpm of seepage from the East Waste Rock Dump Complex in Rattlesnake Gulch would be the same as the No Pit Pond Alternative. Since the thickness of the East Waste Rock Dump Complex would be reduced from approximately 300 feet to 200 feet in the thickest area, the time it takes for the remaining waste rock to become wet to the point ARD exits the dump, would be less. There would be less geochemical uptake of water, and the drying effect of upward air movement that occurs in waste rock dumps would be diminished. The average time until seepage begins would reduce from a range of 50 to 200 years (1997 Draft EIS, Chapter IV, Section IV.B.1.a) to 11 to 24 years (HSI, 2003: Table 6-2). Migration of the 1 to 3 gpm seepage from the base of the East Waste Rock Dump Complex down the Rattlesnake Gulch drainage would be similar to that described for the No Pit Pond Alternative.

4.3.3.2.2.2 Impacts from Pit Seepage

As a consequence of failure of the dewatering system under this alternative, water would rise above the 5,050-foot elevation and discharge as it would under the Partial Pit Backfill With Downgradient Collection Alternative. While it was assumed that 10 percent of pit seepage above the 5,050-foot elevation would exit via bedrock pathways, this seepage has the potential head to flow into the Tdf/colluvial aquifer and Rattlesnake Gulch, therefore the full 15 gpm was modeled. This 15 gpm would reach groundwater and move down Rattlesnake Gulch toward the Jefferson River alluvial aquifer with the 1 to 3 gpm of seepage from the East Waste Rock Dump Complex in Rattlesnake Gulch. The Rattlesnake Gulch interception wells and Tailings Impoundment No. 1 south pumpback system wells would have to be maintained to try to capture this flow. There is minimal chance of impacts to the Jefferson River and Slough from the pit seepage that would bypass the collection system, as long as GSM or its successor continues to operate and maintain the monitoring and pumpback systems and achieves at least 95 percent capture efficiency (HSI, 2003). This would require additional wells to locate flow paths. Ninety-five percent capture efficiency may not be achievable based on GSM's experience with Tailings Impoundment No. 1 seepage, as described in Section 4.2.3.1.2.

4.3.3.3 Reclamation Plan Changes

4.3.3.3.1 Surface Disturbance

The 1997 Draft EIS, Chapter II, Section II.B.7.b estimated that all 254 acres in the pit would be reclaimed with the 4-foot coversoil system under the Partial Backfill Alternative. The Stage 5B pit disturbance area in this SEIS would be 218 acres. The pit would increase by 56 acres to 274 acres due to new haul roads and cast blasting the upper highwall. In this SEIS under the Partial Pit Backfill With In-Pit Collection Alternative, GSM would reclaim all 274 pit acres with the 3-foot coversoil system (Figure 2-4). About 239 of these acres would be on 2H:1V slopes and would require coversoil rock amendments.

Table 4-6 indicates that 1,541,800 cubic yards of soil would be needed to revegetate the pit disturbance in this alternative. GSM does not have enough soil stockpiled to revegetate the pit acres. GSM has approved soil borrow areas from which to obtain soil. One source of cover material is the area northeast of the East Waste Rock Dump Complex, where soil had been obtained in the past. The haul for this material would include approximately 8,250 feet of flat grade and 1,920 feet of 10 percent grade for covering the lower portions of the backfilled pit. In order to haul material to the upper portions of the cast blasted backfill, the haul would consist of a total of 15,280 feet of flat grade and 8,955 feet of 10 percent grade. Additional haul roads would be required to haul soil to cover the reduced highwall.

Under Minor Revision 03-003, GSM is permitted an additional 8 acres of disturbance for a borrow area for the Tailings Impoundment No. 2 embankment construction. This additional area could be utilized for cover material (GSM, 2003c). Some additional disturbance could be required, but no disturbance is proposed by GSM at this time. From the existing borrow area to the pit, the haul would include 2,700 feet of 6 percent grade and 3,250 feet of 3 percent grade. The haul route would be over existing roads for covering the lower portions of the backfilled pit. In order to haul material to the upper portions of the cast blasted backfill, the haul would consist of a total of 16,250 feet of 6 percent grade as shown on Figure 2-4.

4.3.3.3.2 Hazards to Wildlife

The total mine disturbance permitted is 3,002.25 acres (GSM 2003 annual report). GSM has indicated that 2,290 acres would be disturbed through Stage 5B (GSM, 2002a). Additional pit disturbance of 56 acres would be created under this alternative. Even with the additional pit area disturbance, there would be fewer hazards to wildlife than under the No Pit Pond Alternative because the highwall would be eliminated. There would be no hazard to wildlife from exposure to acidic pit water.

4.3.3.3.3 Total Remaining Unrevegetated Acres

In the 1997 Draft EIS and this SEIS, no pit disturbance acres would be left unrevegetated in this alternative, except roads to the dewatering system.

4.3.4 Partial Pit Backfill With Downgradient Collection Alternative

4.3.4.1 Impacts to Groundwater Quality and Quantity

4.3.4.1.1 Risk of Impacts to Groundwater Quality and Quantity in Permit Area

4.3.4.1.1.1 Impacts from Waste Rock Dump Seepage

Waste rock removed for backfill material under this alternative would be the same as the Partial Pit Backfill With In-Pit Collection Alternative, except that no crusher reject would be used. The impacts of this alternative on groundwater resources and geochemistry of seepage from the East Waste Rock Dump Complex would be the same as the Partial Pit Backfill With In-Pit Collection Alternative except 1 to 3 gpm of seepage would travel down Rattlesnake Gulch with 16 gpm of pit seepage (Telesto, 2003a).

4.3.4.1.1.1.1 Long-Term Monitoring and Mitigation for Unanticipated East Waste Rock Dump Complex Seepage

Long-term monitoring and mitigation for unanticipated East Waste Rock Dump Complex seepage would be the same as for the No Pit Pond Alternative and all other alternatives.

4.3.4.1.1.1.2 Summary of East Waste Rock Dump Complex Seepage Impacts to Water Quality and Water Quantity

Impacts to groundwater under this alternative would be essentially the same as the No Pit Pond Alternative and all other alternatives except 1 to 3 gpm of seepage would travel down Rattlesnake Gulch with 16 gpm of pit seepage.

4.3.4.1.1.2 Impacts from Pit Seepage

The Partial Pit Backfill With Downgradient Collection Alternative would not maintain the pit as a hydrologic sink. Instead, the water table would be allowed to rebound and reach a steady state at the 5,260-foot elevation. Groundwater leaving the pit would be collected from wells located down gradient of the pit. At least 10 new monitoring wells and 26 additional groundwater capture wells may be required to intercept contaminated water. More wells may be needed based on hydrogeologic studies completed to identify flow paths. The wells would be installed in the T/Q alluvial and bedrock aquifers in drainages and along faults at various depths (Figure 2-7). This alternative would rely on a combination of partial attenuation, mixing with ambient groundwater, and collection to prevent contaminated pit seepage from impacting groundwater outside of a permitted mixing zone.

Capture well systems can be complex. The bedrock geology around the GSM pit may make it difficult to locate the seepage and construct wells adequate to capture all seepage. Collected water would be treated in the water treatment system and released in a percolation pond below Tailings Impoundment No. 2. Although some attenuation would help prevent impacts outside of the mixing zone in the short term, the available capacity is limited for effective, long-term attenuation along the primary pit outflow groundwater flow path. Attenuation would be limited because of historic flows of ARD along the flow path as indicated by ferricrete deposits in the area (HSI, 2003).

The geochemical conditions and evolution of groundwater quality in a backfilled pit were described by Telesto (2003c). The waste rock in the East Waste Rock Dump Complex has had 1 to 20 years to weather the sulfide by taking on oxygen and water. Wetting of the sulfide causes a heat-producing reaction, which drives the water off as steam. As a result, the waste rock is covered with oxidation by-products, such as acid salts. Placing this weathered waste rock in the pit as backfill and allowing it to become saturated would mobilize these oxidation byproducts.

The waste rock placed in the unsaturated, oxidizing environment in the pit backfill would continue sulfide oxidation even though the chimney effect present in the waste rock dump complexes would not be present in the backfilled pit. The accumulating groundwater in the backfill prior to pit outflow would have a chemical composition similar to that of the unsaturated zone with potentially higher concentrations due to the dissolution of the oxidation products. The oxidation of sulfide would be driven by both oxygen and ferric iron in the unsaturated zone above the water table in the pit, and would be driven by ferric iron in the saturated zone.

Over the long term, the oxidation state of the deeper portion of the saturated backfill would decline due to the limited circulation of oxygen and reduction in the rate of sulfide oxidation (Telesto, 2003c). Until the existing amount of jarosite (ferric iron oxide) is dissolved and flushed from the system, it is likely that little change would be noticeable. Based on the water balance and rate of groundwater circulation through the pit, the pit discharge water quality until the backfill is saturated would likely resemble that listed in Table 4-5. As groundwater moves through the saturated backfill, water quality would gradually change. At least 200 to 300 years of this flushing through the backfill would be needed to remove the initial pore water in the backfill (Telesto, 2003e). Thus, at a minimum it would be 200 to 300 years before the water quality from the pit could begin to improve.

The ultimate quality of the groundwater discharging from the pit would be influenced by the rates of groundwater circulation through various depths of the pit backfill, ARD input from the unsaturated backfill via recharge, and the locations and elevations of the various pathways by which groundwater would leave the pit.

Hydrogeologic evaluations indicated that most of the total 16 gpm discharge from a backfilled pit would occur to the east, from the Sunlight/Range Front Fault and across and along the Corridor Fault from the 5,050 to 5,260-foot elevation (Telesto, 2003a).

The rest of the discharge seepage would be expected to leave the pit through subsurface geologic structures directly connected to the deeper saturated portions of the pit backfill (see Section 3.3.7 for a flow path discussion).

The 1997 Draft EIS, Chapter IV, Section IV.B.7.b indicated that groundwater from a backfilled pit would exit through the colluvium at the east side of the pit (Hydrometrics, 1995). An evaluation of the groundwater flow paths through a backfilled pit was performed for this SEIS using a two-dimensional (cross-section) flow net analysis with existing hydrologic boundary conditions (Telesto, 2003e). Flow time through the pit would range from 68 to 154 years, from top to bottom of the pit, respectively. Stagnation zones were not found to be probable in the analysis. This means that most water that migrated through the deep portion of the pit would eventually flow out of the pit at a higher elevation (i.e., out the Corridor Fault or similar flow path).

The flow net generated from the model indicated that precipitation recharge, which would migrate through the unsaturated portion of the pit, makes up approximately 25 percent of the total pit outflow. Another 25 percent of the pit outflow would contact a zone of waste rock that fluctuates between unsaturated and saturated conditions. Thus, roughly half of the pit discharge would be directly influenced by sulfide oxidation processes in the unsaturated zone of the backfill, and would continue to transport ARD. The remaining half of the pit discharge will not likely contact unsaturated waste rock, but would be affected by the dissolution of sulfide oxidation products remaining in the deeper backfill. It is projected that it would be on the order of hundreds of years before the existing sulfide oxidation products are flushed from the upper portions of the backfill. Additionally, the remaining jarosite could maintain redox conditions that produce ARD beyond the hundreds of year time frame. (Telesto, personal communication, September 2004).

The combination of rinsing accumulated ARD products and continued oxidation in both the saturated zone and unsaturated zone would result in the discharge of low-pH, metal-bearing groundwater for at least 200 to 300 years. The water chemistry provided in Table 4-5 is appropriate for describing the probable composition of groundwater discharge from the pit for this period. Beyond the initial saturation period, while the quality of groundwater in the permanently saturated zone may be improved over that derived from the unsaturated zone, the overall quality of the actual discharge may or may not improve, as approximately 8 gpm or 50 percent of the pit discharge is derived from rain and snow melt recharge through the unsaturated backfill (Telesto, 2003e).

As documented in the 1997 Draft EIS, Chapter III, Section III.B.2.b, Table III-1, the quality of groundwater in the Tdf/colluvial aquifer is impacted by natural mineralization. Table III-1 indicated that the groundwater in Rattlesnake Gulch had a geometric mean pH of 4.3, sulfate of 731 mg/l, aluminum of 6.5 mg/l, copper of 0.43 mg/l, zinc of 0.54 mg/l, and nickel of 13.03 mg/l based on GSM monitoring wells PW-47, PW-63, PW-12 and PW-8 (shown on Figure 3-5). Much of the Tdf/colluvial aquifer has an alkalinity of 30 mg/l or less.

The water balance indicated a pit discharge of 16 gpm, having a pH of 2.2, sulfate of 22,400 mg/l, aluminum of 1,410 mg/l, copper of 55.9 mg/l, zinc of 21.3 mg/l, and nickel of 13.03 mg/l (Telesto, 2003a, c). Groundwater discharge of a backfilled pit to the Tdf/colluvial aquifer in Rattlesnake Gulch would cause some additional deterioration of water quality, including increasing acidity and dissolved metals concentrations. Mixing the pit effluent of 16 gpm with the expected range of 52 to 103 gpm of groundwater of upper Rattlesnake Gulch would result in an approximate average 5-fold increase in sulfate concentration, and a 10-fold increase in copper concentration, assuming no chemical or physical reactions of these contaminants. The basis of these estimates is provided in Table 4-7. Other metals would also increase in concentration. Upper Rattlesnake Gulch lies within GSM's permitted mixing zone. The mixing zone does not include the pit as a source of discharge.

The natural properties of the Tdf/colluvial aquifer to attenuate ARD contaminants from the additional chemical mass contributed to the existing mixing zone by groundwater discharge from the backfilled pit and the 1 to 3 gpm seepage from the East Waste Rock Dump Complex were evaluated (Telesto, 2003e). The analysis included acid/base reactions, silicate dissolution, sorption, ion exchange, oxidation-reduction reactions, and mixing.

Unlike the Bozeman Group aquifer, samples of the Tdf/colluvial aquifer do not include identified calcareous zones or carbonate cementation (SHB, 1981-1989; Golder, 1995). The lack of visual identification of carbonates indicates they constitute less than a few percent of the Tdf/colluvial aquifer material. Since the precise amount of carbonates in the Tdf/colluvial aquifer is difficult to quantify, the potential neutralization capacity can be assessed by checking the theoretical quantity of carbonates required to neutralize the amount of acidity projected to emanate from the East Waste Rock Dump Complex and the pit.

The amount of acidity discharged in the 1 to 3 gpm from the 13 percent of the East Waste Rock Dump Complex that overlies the Tdf/colluvial aquifer could be neutralized with a calcium carbonate content by weight of 1.8 percent in the Tdf channel, which runs from up gradient of Tailings Impoundment No. 1 to the Jefferson River alluvial aquifer (Telesto, 2003e). This amount of carbonate could occur in the Tdf/colluvial aquifer, thus 1 to 3 gpm of seepage from the East Waste Rock Dump Complex could be neutralized within the Tdf/colluvial aquifer. This acidity neutralization potential is the same for all alternatives.

Based on the amount of sulfide available to be oxidized in the unsaturated portion of the backfill, the Tdf/colluvial aquifer below Tailings Impoundment No. 1 would need a calcium carbonate content of 59 percent to neutralize the acidity of the of 16 gpm pit discharge. These calculations are based on 100 percent neutralizing efficiency, which does not occur under field conditions. Therefore, although neutralization of the 1 to 3 gpm of East Waste Rock Dump Complex seepage could occur, there would be no long-term attenuation of pit discharge by acid-base reactions (Telesto, 2003e).

Table 4 - 7 Estimated Impacts to Groundwater Quality in the Tdf/Colluvial Aquifer From Pit Effluent

	Higher Estimated Groundwater Flow Rate In Tdf/Colluvial Aquifer		Lower Estimated Groundwater Flow Rate In Tdf/Colluvial Aquifer		
	SULFATE		**SULFATE**		
Discharge of Pit to Tdf	15	gpm	15	gpm	Telesto, 2003a
Flow Rate in Tdf	103	gpm	52	gpm	Rattlesnake Wells 98-03
Mixed Rate	118	gpm	67	gpm	
Sulfate in Pit	22,400	mg/l	22,400	mg/l	Telesto, 2003c
Sulfate in Tdf	984	mg/l	984	mg/l	Avg. PW-12, 63, 64
Mixed Sulfate	3,706	mg/l	5,779	mg/l	
Change	**380**	%	**590**	%	
	COPPER		**COPPER**		
Discharge of Pit to Tdf	15	gpm	15	gpm	Telesto, 2003a
Flow Rate in Tdf	103	gpm	52	gpm	Rattlesnake Wells 98-03
Mixed Rate	118	gpm	67	gpm	
Copper in Pit	56	mg/l	56	mg/l	Telesto, 2003c
Copper in Tdf	0.96	mg/l	0.96	mg/l	Avg. PW-12, 63, 64
Mixed Copper	7.96	mg/l	13.28	mg/l	
Change	**830**	%	**1,380**	%	

Limited neutralization potential could be provided by silicate dissolution for groundwater solutions with a pH below about 2.5 (Telesto, 2003c). The kinetics of acid neutralization by silicate dissolution are relatively slow. While this process is known to occur in the East Waste Rock Dump Complex, which is unsaturated and has relatively low seepage rates of 9 to 21 gpm and water velocity less than 8.8×10^{-7} cm/s, silicate dissolution is not expected to be an important factor for pit seepage in the Tdf/colluvial aquifer where groundwater flux is relatively rapid and contact time minimal. Flow rates in the Tdf/colluvial aquifer with pit and East Waste Rock Dump Complex seepage would be 68 to 121 gpm through an aquifer cross-section of 0.1 to 1.6 acres, with groundwater velocities of 1.8×10^{-4} to 4.9×10^{-4} cm/s (HSI, 2003).

Of the attenuation processes considered, ion exchange and sorption reactions are the ones likely to play a major role in attenuation of metals and acidity from GSM pit discharge. Based on the geologic descriptions of the Tdf/colluvial aquifer, it was assumed that the clay content included 1 percent smectite and 3 percent kaolinite clay, and 2 percent iron oxide cementation (Telesto, 2003e). A cation exchange capacity (CEC) was assigned for each of the clay and material types found in the Tdf/colluvial aquifer based on published data. CEC is the amount of exchangeable cations that a soil can adsorb at pH 7.0 (U.S. Department of Agriculture, 2003). CEC is a measure of the net negative charge of a soil and is related to the organic matter content and kind and amount of clay present in the soil. The effective CEC of the Tdf/colluvial aquifer was estimated to be 3.15 milliequivalents per 100 grams (HSI, 2003). This means that

3.15 milliequivalents (millimoles of a constituent divided by its valence state) of a constituent can become associated with 100 grams of clay particles in the Tdf/colluvial aquifer.

These calculations tend to overestimate the attenuation that would likely occur, because the calculations assumed that all of the constituents have an equal likelihood of sorbing to the available material and that the clays and iron oxides are uniformly distributed within the Tdf/colluvial aquifer and in full contact with the water. This is not the case in natural systems (HSI, 2003).

A mass balance calculation to determine the ion exchange capacity of the Tdf/colluvial aquifer was performed using the CEC value and the aquifer volumes presented above (Telesto, 2003e; HSI, 2003). The mass balance calculated the total mass of constituents that the aquifer could capture by the cation exchange process and balanced that against the mass flux through the aquifer. The mass balance calculation was performed for two scenarios:

- Existing 103 gpm of Tdf/colluvial aquifer groundwater mixed with 1 to 3 gpm East Waste Rock Dump Complex drainage that would impact the aquifer. This is the condition that would prevail whether pit seepage occurred or not (such as in the No Pit Pond Alternative); and,
- Taking the 104 to 106 gpm of water and mixing the expected 16 gpm (with sensitivity testing up to 24 gpm) of pit seepage under the Partial Pit Backfill With Downgradient Collection Alternative.

As discussed in HSI (2003) and Telesto (2003a and 2003e), the 1 to 3 gpm of seepage from the East Waste Rock Dump Complex would be expected to occur prior to discharge from the backfilled pit. Therefore, the waste rock dump seepage was factored into the baseline condition for Rattlesnake Gulch that would exist at the time the pit seepage would impact the Tdf/colluvial aquifer.

The Tdf/colluvial aquifer was divided into relatively uniform segments based on the detailed hydrogeologic data available from previous GSM studies (Golder, 1995; Hydrometrics, 1994, 1995, 1997; Keats, 2001, 2002). Rates of recharge to the aquifer segments were made to match the flow rates in the Tdf/colluvial aquifer indicated by the geometry, hydraulic gradient and physical properties of the aquifer. The agencies have assumed that 10 percent of pit seepage would discharge out of the pit at other locations. Dilution was accounted for by mixing the remaining 14.4 gpm of pit effluent with the rate of discharge in successive segments of the Tdf/colluvial aquifer from the pit. Pit seepage would eventually mix with the 99 gpm flow of the Jefferson River alluvial aquifer within the GSM permit boundary. A hydrogeologic characterization of the Tdf/colluvial aquifer was performed (Table 6-4 in HSI, 2003). A mixing model was developed (Telesto, 2003e). Recharge was added to mixing cells to balance the predicted range of groundwater flow within the aquifer (52 to 103 gpm), and a water chemistry of well MW-200, a monitoring well mid-way along the Tdf/colluvial aquifer flow path (Figure 3-5). As discussed in Section 4.3.2.1.1.1.2, the 13 percent of the East

Waste Rock Dump Complex overlying the Tdf/colluvial aquifer was predicted to contribute approximately 1 to 3 gpm of ARD seepage to groundwater at a future time, in the range of 33 to 87 years (HSI, 2003), prior to the discharge from the pit, thereby providing a higher baseline concentration of these parameters than current conditions.

The downgradient groundwater collection for the Partial Pit Backfill With Downgradient Collection Alternative would be accomplished by a series of at least 26 capture wells near or slightly west and south of the current Rattlesnake Gulch interception wells (HSI, 2003). These include 10 within the throat of Rattlesnake Gulch, near the current capture wells, and 16 on secondary bedrock pathways. The 16 capture wells on bedrock pathways included two at each of the eight bedrock structure locations identified in Section 2.4.4.3 and Figure 2-7. Based on GSM's experience with pumpback systems, it is estimated that at least 10 wells would be installed to intercept groundwater with a likely maximum of 80 percent recovery efficiency across the 800-foot-wide Tdf/colluvial aquifer in the vicinity of the Rattlesnake Gulch interception wells. A consultant has concluded that an evaluation of the Tailings Impoundment No. 1 south pumpback system indicated that contaminant capture efficiency can exceed 95 percent with intensive groundwater interception and monitoring (HSI, 2003). The agencies have concluded that 95 percent capture efficiency may not be achievable in the complex hydrogeologic setting in the secondary bedrock pathways, based on GSM's experience as described in Section 4.2.2.1.2. The captured groundwater would be sent to the water treatment plant.

The pit would discharge under this alternative. Groundwater quality would likely deteriorate up gradient of the collection wells in an area where groundwater is already impacted by ARD from natural mineralization and by future seepage from the 13 percent of the East Waste Rock Dump Complex that overlies Rattlesnake Gulch. The pit discharge of 16 gpm was not included in the 1998 Final EIS, Appendix 1 mixing zone analysis.

In contrast to the Partial Pit Backfill With In-Pit Collection Alternative, this alternative would allow the pit groundwater level to rebound and discharge down gradient. During backfilling over 3 years, groundwater could not be collected in the sump in the underground workings. Access to the underground would be lost as soon as backfilling operations were initiated. During and after backfilling, the groundwater level in the pit would slowly rise, saturating the backfill. Eventually, the groundwater within the backfill would establish a hydrologic steady state with the natural groundwater system around the pit. The 1997 Draft EIS, Chapter IV, Section IV.B.7.b predicted that the water table under the Partial Backfill Alternative would rise to the 5,050-foot elevation and begin to discharge to the Tdf/colluvial aquifer (Hydrometrics, 1995). The discharge rate estimated in the 1997 Draft EIS was 50 gpm. New information was analyzed for this SEIS to update this prediction.

Based on the water balance performed for this SEIS (Telesto, 2003a), seepage of groundwater from the pit backfill would begin approximately 35 years after mining ceases, when the groundwater level reached the 5,050-foot elevation. At this point, only about 26 percent of the backfill would be saturated. A steady state pit groundwater elevation of 5,260 feet would be reached approximately 123 years following the cessation of mining, when 67 percent of the backfill would be saturated (Telesto, 2003a). The discharge rate from the pit would be approximately 16 gpm. Therefore, the 1997 Draft EIS overestimated the amount of water that the pit would discharge.

As presented in Section 3.3.6, a local groundwater divide exists within the low point on the eastern rim of the open pit at the 5,211-foot elevation. From this point, the groundwater potentiometric gradient declines toward the hydrologic sink maintained in the pit to the west, and it declines abruptly to the Range Front Fault and the Tdf/colluvial aquifer to the east (see Figure 3-7). In a backfilled pit without water level control, groundwater levels are predicted to reach a steady state at the 5,260-foot elevation (Telesto, 2003a), which is approximately 50 feet above the current groundwater divide elevation as measured in PW-64 (Figure 3-5) (HSI, 2003). Although the Corridor Fault is believed to be relatively permeable, the pit backfill would continue to weather, forming oxidation byproducts and becoming less permeable over time. It requires a hydraulic head to move groundwater through the backfill to the fault to discharge from the pit.

Under the Partial Pit Backfill With Downgradient Collection Alternative, groundwater would saturate over 67 percent of the backfilled pit, and the water level would encounter the Corridor Fault at an elevation between 5,150 and 5,250 feet (Telesto, 2003a). The Corridor Fault is shown to have a minimal contact area at the 5,050-foot elevation on the north side of the pit. The hydraulic head on the north side of the pit is higher than the water levels in the pit (i.e., this is the upgradient or inflowing side of the pit). Thus, the majority of the water cannot flow from the pit through the Corridor Fault until it reaches the 5,150-foot elevation on the downgradient side of the pit.

The Corridor Fault was identified in Section 3.3.7.2 as the primary pit flow path (HSI, 2003). The thick Quaternary-age gravel and debris flow deposits east of the Range Front Fault on the eastern rim of the pit, as mapped by Chadwick (1992), are hydrologically connected to the Tdf/colluvial aquifer in the upper Rattlesnake Gulch (URS, 2001; HSI, 2003). The majority of pit outflow is expected to migrate through the Corridor Fault and be conveyed to the Tdf/colluvial aquifer along and across the Range Front Fault (Gallagher, 2003a; HSI, 2003; Telesto, 2003a; URS, 2001).

As described in Section 3.3.1.4, the Tdf/colluvial aquifer is a buried gravel deposit forming a continuous groundwater pathway from the east edge of the pit and south through Rattlesnake Gulch, where it blends with the T/Q alluvial aquifer beneath Tailings Impoundment No. 1, reaching to the Jefferson River alluvial aquifer (HSI, 2003). The existence and extent of this flow path was mapped from geologic data in a number of detailed studies since 1982 (HSI, 2003). A map of the groundwater flow paths from the pit is provided in Figure 3-8 (HSI, 2003).

The 1997 Draft EIS, Chapter IV, Section IV.B.1.e predicted that the groundwater base flow captured below Tailings Impoundment No. 1 in Rattlesnake Gulch would be 200 gpm. New analyses based on additional information were conducted for this SEIS (HSI, 2003). The quantity of groundwater flow through the buried Tdf/colluvial aquifer in upper Rattlesnake Gulch north of Tailings Impoundment No. 1 has been estimated from existing data. The flow rate estimated with channel geometry data from Golder (1995a), geometric mean permeability from Golder (1995a) and SHB (1987) of 3.6 feet/day, and the new potentiometric map (HSI, 2003) indicates the ambient discharge would be a maximum of 103 gpm. The existing interception wells located in the upper portion of Rattlesnake Gulch above the Tailings Impoundment No. 1 produced a combined average of 52 gpm from 1998 through mid-2003 (GSM, 2002a), with intermittent weekly production rates up to 180 gpm.

4.3.4.1.1.2.1 Impacts to Water Quality

The Partial Pit Backfill With Downgradient Collection Alternative is the only alternative studied in detail that would not maintain the pit as a hydrologic sink. Groundwater capture efficiency of 95 percent or greater would be required to meet water quality standards in the Jefferson River alluvial aquifer (HSI, 2003). Groundwater discharging from the pit along the primary flow path would be captured by a series of wells in upper Rattlesnake Gulch and the existing Tailings Impoundment No. 1 south pumpback system (Figure 3-5). Continued dewatering in the Rattlesnake Gulch drainage is an unavoidable impact of the groundwater capture system. Ninety-five percent capture efficiency may not be achievable, as described in Section 4.2.3.1.2.

Degradation of groundwater quality would likely occur up gradient of the collection wells in an area where groundwater is already impacted by ARD from natural mineralization and may eventually be impacted from 13 percent of the East Waste Rock Dump Complex. Although this area is within the permitted GSM mixing zone, pit sources are not specifically included, and DEQ review of the permit would be triggered.

The higher pit groundwater elevation under this alternative could lead to migration of ARD water from the pit along secondary flow paths in the bedrock aquifer and Bozeman Group aquifer where it is more difficult to detect and collect. As provided in mitigation Measure W-10 in the 1998 Final EIS, additional hydrogeologic studies and monitoring, along with at least 26 groundwater capture wells, would be needed to attempt to comply with applicable standards. Some seepage would still escape the capture system. This SEIS suggests augmenting the existing monitoring well network with at least 10 additional monitoring wells.

The pit backfill analog study conducted for this SEIS did not find any hardrock mine in the U. S. or Canada in which such a large pit was backfilled and allowed to become saturated with groundwater (Gallagher, 2003c). No long-term water quality monitoring records exist at the backfilled mines or flooded underground mines studied sufficient to indicate whether the reclamation goals at those mines were achieved.

4.3.4.1.1.2.2 Impacts to Water Quantity

This alternative poses a greater risk than the Partial Pit Backfill With In-Pit Collection Alternative of creating new springs or seeps impacted by ARD from the pit or increased discharges of ARD at existing springs around the pit area. Such new or increased sources of contaminants would be within GSM's current mine-wide mixing zone. Pit sources are not part of the currently approved sources and would trigger a permitting review by the DEQ.

4.3.4.1.1.2.3 Summary of Pit Impacts to Water Quality and Quantity

The Partial Pit Backfill With Downgradient Collection Alternative does not maintain the pit as a hydrologic sink. It relies on the success of pumpback wells to capture and treat the groundwater in the permanent water treatment plant. Ninety-five percent capture efficiency is required but may not be achievable.

4.3.4.1.2 Risk of Violation of Groundwater Standards at the Permit Boundary and Impacts to Beneficial Uses of the Jefferson River Alluvial Aquifer

4.3.4.1.2.1 Impacts from Waste Rock Dump Seepage

Impacts from 1 to 3 gpm of seepage from the East Waste Rock Dump Complex in Rattlesnake Gulch under this alternative would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative.

4.3.4.1.2.2 Impacts from Pit Seepage

4.3.4.1.2.2.1 Impacts to Water Quality

Any uncaptured water originating from the pit would eventually migrate to the Jefferson River alluvial aquifer at the southern limit of the GSM permit area through the alluvial channel, or the underlying Bozeman Group aquifer. The Jefferson River alluvial aquifer consists of the stream deposits laid down by the Jefferson River. The width of the Jefferson River alluvial aquifer is approximately 1,000 feet, from its northern limit to the closest point on the Jefferson River Slough within the GSM permit boundary (Figure 3-6). Geologic logs of GSM and private wells indicate that the saturated thickness of coarse sand, gravel and cobbles averages about 20 feet in the area along Interstate 90 and the Jefferson River Slough (HSI, 2003). Based on Jefferson River alluvial aquifer properties from previous studies, it is estimated that approximately 99 gpm of groundwater flows through the Jefferson River alluvial aquifer within the GSM permit boundary (HSI, 2003). The hydrologic and water quality parameters of the Jefferson River alluvial aquifer are provided in HSI (2003).

The alternatives analyzed in the1997 Draft EIS did not include a scenario in which the pit would be permitted to freely discharge without being maintained as a hydrologic sink.

In addition, the 1997 Draft EIS, Chapter IV, Section IV.B.1.a found that there would be no impacts to the Jefferson River alluvial aquifer at any future time due to seepage from the waste rock dumps. The 1997 Draft EIS did not specifically analyze the rate of flow or attenuation potential of the Jefferson River alluvial aquifer.

A mass water balance was calculated using 16 gpm of pit seepage, obtained from the pit water balance (Telesto, 2003a), mixed with the 52 to 103 gpm of ambient groundwater, based on Rattlesnake Gulch interception wells and Darcy Law groundwater flux. The Tdf/colluvial aquifer would have the theoretical capacity to attenuate 1.9 to 2.8 pore volumes of pit discharge-ambient groundwater mixture before the exchange capacity of the aquifer materials would reach a steady state with the groundwater (HSI, 2003). Since the 1 to 3 gpm of seepage from the 13 percent of the East Waste Rock Dump Complex over the Tdf/colluvial aquifer may reach the aquifer first, little or no attenuation capacity may remain for the pit-impacted groundwater. With 80 percent groundwater capture efficiency by the Rattlesnake Gulch collection wells that would be required for this alternative, the Tdf/colluvial aquifer below this point would only have 10 to 20 years of attenuation capacity (HSI, 2003). Since the exchange process is reversible, metals that were sorbed onto the aquifer materials could be remobilized by additional ARD seepage. Therefore, over the long term, the Tdf/colluvial aquifer would not attenuate ARD, and only mixing and collection would reliably serve to mitigate potential impacts.

A dynamic systems model (DSM) was run, as described in Section 4.3.2.1.1.1.2, to simulate the effects of capture efficiency and mixing from recharge on the pit seepage impacts to the Tdf/colluvial aquifer and Jefferson River alluvial aquifer (Telesto, in HSI, 2003). With the upper Rattlesnake Gulch capture system at 80 percent efficiency, the model predicts groundwater quality standards would be exceeded within the Jefferson River alluvial aquifer for copper and nickel (WQB-7; DEQ, 2004). Copper was predicted to reach 1.3 to 1.4 mg/l compared with the groundwater quality standard of 1.30 mg/l. Nickel was predicted to reach 0.30 to 0.34 mg/l compared with the groundwater quality standard of 0.10 mg/l. The standard for nickel would be exceeded by the largest margin. Sulfate in the Jefferson River alluvial aquifer was predicted to reach 1,000 to 1,200 mg/l, roughly 1.75 times the current average baseline level.

The DSM indicated that a capture efficiency of 95 percent or greater would be required to achieve compliance with groundwater standards for nickel and the other metals at the mixing zone boundary. Compliance with these parameters would indicate that the current groundwater classification under ARM 17.30.1006 remains unchanged. Under existing conditions, groundwater remaining in the Tdf/colluvial aquifer below Tailings Impoundment No. 1 would encounter the south pumpback system. Bulk capture efficiencies over 95 percent have been estimated in an evaluation of cyanide capture below Tailings Impoundment No. 1 south pumpback system (Hydrometrics, 1994; HSI, 2003). Achieving this level of capture efficiency for effluent out of the pit is not as likely due to longer, more complex and heterogeneous flow paths in alluvial, sedimentary, and bedrock aquifers. These probable lower capture efficiencies combined with a lack of attenuation capacity in the flow paths (HSI, 2003) and the possibility of not identifying discrete flow paths (Keats, 2001) result in a greater risk of not meeting water quality standards. If an overall capture efficiency of 80 percent were assumed, the combined theoretical efficiency of the Rattlesnake Gulch wells and south pumpback system wells could be 96 percent. However, the agencies have concluded that an overall 95 percent capture efficiency may not be achievable based on GSM's experience with Tailings Impoundment No. 1, as described in Section 4.2.3.1.2.

Keats (2001) concluded the second and third rows of pumpback wells were not completely capturing the seepage. Keats recommended treatment at the source area rather than adding pumpback wells. This was due in part to the difficulty in defining smaller scale contaminant pathways. The agencies have concluded that an overall 95 percent capture efficiency may not be achievable based on GSM's experience with Tailings Impoundment No. 1, as described in Section 4.2.3.1.2. GSM has been conducting studies of reclamation and in-situ treatment methods to prevent contaminants from Tailings Impoundment No. 1 from migrating to groundwater (GSM 2003 annual report). If successful, by the time Stage 5B mining and backfilling would be completed, the existing pumpback systems below Tailings Impoundment No. 1 may not be needed for control of contaminants. This SEIS analysis indicates that the continued operation of the south pumpback system would be needed to attempt control of contaminants of 16 gpm of pit seepage mixed with the 1 to 3 gpm of East Waste Rock Dump Complex seepage and naturally mineralized groundwater. Long-term downgradient monitoring would be required to assure continued compliance.

Contingency measures for additional groundwater capture, such as Measure W-4 approved in the 1998 ROD as Stipulation 010-7, would be necessary for implementation of this alternative in the absence of the Tailings Impoundment No.1 south pumpback system. Measure W-4 requires monitoring of groundwater at the mixing zone boundary and establishment of additional capture wells as a contingency under the GSM operating permit. If the pit is allowed to discharge under this alternative, groundwater quality would likely deteriorate up gradient of the collection wells in an area where groundwater is already impacted by ARD from natural mineralization and by seepage from the 13 percent of the East Waste Rock Dump Complex that overlies Rattlesnake Gulch. The pit discharge of 16 gpm was not included in the 1998 Final EIS, Appendix 1 mixing zone analysis. The agencies have concluded that the two collection systems would be needed to attempt capture of 95 percent of the seepage and would be bonded for in the operating permit to minimize impacts to the Jefferson River alluvial aquifer. The agencies have concluded that an overall 95 percent capture efficiency may not be achievable based on GSM's experience with Tailings Impoundment No. 1, as described in Section 4.2.3.1.2. If this alternative is the preferred alternative in the final SEIS, DEQ would modify the 1998 Statement of Basis for the mixing zone.

Secondary groundwater flow paths were not identified in the 1997 Draft EIS. As the groundwater level rises in the pit backfill under this alternative to the 5,260-foot elevation, the agencies have assumed that 10 percent of the 16 gpm of pit discharge, or 1.6 gpm, would also migrate into fractures, faults and other geologic structures in the bedrock forming the pit highwall (HSI, 2003). Many of these structures provide the pathways for the seeps and springs discharging into the pit during mining (Gallagher, 2003b). The additional flow pathways are called "secondary" because their extent and continuity outside the pit may be limited or incompletely mapped, their hydrologic connection to existing surface water or groundwater features may be indirect, or their importance is inferred primarily by association with ferricrete deposits or high-yield wells, which provide indirect evidence of a pathway.

The Precambrian LaHood Formation, which is the bedrock hosting the ore body, has little to no natural attenuation capacity (Schafer and Associates, 1994). This rock may produce leached acidity and metals naturally, in the absence of mine drainage. Thus, any ARD migrating out of a saturated backfilled pit through bedrock structures would not likely be attenuated within the bedrock aquifer.

Due to the uncertainty of secondary groundwater flow paths in the bedrock, groundwater monitoring along known, hydrologically important geologic structures would be a component of this alternative. A review of the existing groundwater monitoring well network in the bedrock aquifer surrounding the pit was performed (HSI, 2003). A summary of the pertinent geologic structures, along with the degree of existing monitoring and recommendations for monitoring wells, is provided in Table 4-8. It indicates that at least 10 monitoring wells on geologic structures and other pathways would be required for this alternative. The potential locations of these wells are shown on Figure 2-7.

Groundwater capture wells on secondary pathways would be a contingency. The wells would not be installed until monitoring indicated a need. Based on previous studies of groundwater capture in bedrock (Hydrometrics, 1995) and experience in drilling wells at GSM, it is estimated that at least two capture wells would initially be required for each structure with evidence of ARD migration. Testing and monitoring would be required to determine whether two wells achieved sufficient capture efficiency. More wells may be needed based on hydrogeologic studies.

Appendix B in the 1997 Draft EIS provided an analysis in support of a source-specific groundwater mixing zone for GSM. It included an assessment of groundwater capture in the fractured bedrock south of the pit around the West Waste Rock Dump Complex. This assessment concluded that capture efficiencies of 80 percent or greater were theoretically achievable in the fractured bedrock. A capture efficiency of 80 percent resulted in meeting all water quality standards for all metals except copper. An efficiency of 85 percent would result in compliance for copper. This is potentially achievable within the possible range of capture efficiencies. As noted in the 1997 Draft EIS, Appendix B, additional hydrogeologic characterization or capture wells may be required to meet these efficiencies.

Table 4 - 8 Anticipated Monitoring Sites for Groundwater Flow Paths out of a Saturated Pit

Flow Path[1]	Existing Monitoring Locations	Additional No. of Monitoring Wells	Comments
Primary Pit Flow Path			
Corridor Fault	None	2	Suggested locations are north of the key cut at the northeast corner of the pit rim
Range Front Fault	PW-4, PW-58, PW-59, PW-60	1	Suggested location is at or near mine parking lot, designed to intersect the fault
Tertiary Debris Flow Channel	PW-8, PW-11, PW-12, PW-63, MW-202, MW-200, Rattlesnake Spring, Bunkhouse Springs	0	Includes wells north of Tailings Impoundment No. 1 with the exception of the Rattlesnake Gulch interception wells
Secondary Pit Flow Paths			
Bozeman Group Aquifer	EFPB-21	2	Assumes EFPB-21 well would be available. Suggested locations are near the Old Assay Lab and the Buttress Dump
Sunlight Syncline	Stepan Spring, PW-17	1	Suggested location is east of PW-6 well near intersection of Sunlight Syncline and Telluride Zone
Sunlight PDZ	None	2	One suggested location is east of PW-6 well near intersection of Sunlight PDZ and Telluride Zone, a second location to the southeast
Telluride Zone	PW-6	0	Would be covered by wells for Sunlight Syncline and Sunlight PDZ

Latite Valley PDZ	PW-21 and Arkose Valley /Sunlight Springs Trench Drain	2	Suggest at least two additional monitoring wells to be located on the west ridge of pit near intersection of Latite Valley PDZ/Fenner Fault/Lone Eagle Fault
Fenner Fault	None	0	See Latite Valley PDZ
Lone Eagle Fault	None	0	See Latite Valley PDZ
St Paul Gulch PDZ	St Paul Gulch Spring	0	Spring monitoring should continue

[1] As modified from HSI (2003). See Figure 3-1 for fault locations and Figure 2-7 for monitoring well locations.

4.3.4.1.2.2.2 Impacts to Water Quantity

Appendix B and Appendix L of the 1997 Draft EIS evaluated groundwater capture efficiency from fractures in the bedrock aquifer using a flow rate consisting of 12 gpm of ambient groundwater flux plus 5 gpm of net seepage to groundwater from the West Waste Rock Dump Complex, for a total of 17 gpm flux at the capture wells. This SEIS reviewed the 1997 Draft EIS and applied this evaluation to the capture of seepage from a backfilled pit with downgradient collection. The rate of groundwater flux through secondary bedrock flow paths (faults, fractures and other geologic structures) from a backfilled pit not maintained as a hydrologic sink was estimated to be roughly 10 percent of the total pit outflow of 16 gpm, or 1.6 gpm, based on best professional judgment. The SEIS analysis of the groundwater impacts from a backfilled pit with downgradient collection found that an additional 1.6 gpm could be expected at downgradient capture wells in the bedrock aquifer. This additional flow is relatively minor and is adequately encompassed within the range of variability inherent in the capture analysis of the 1998 Final EIS.

The Partial Pit Backfill With Downgradient Collection Alternative would result in 1.6 gpm of pit seepage along secondary flow paths around the pit due to the higher hydraulic head in the pit relative to the groundwater elevations surrounding the pit (HSI, 2003).

Following implementation of the Partial Pit Backfill With Downgradient Collection Alternative, the presence of new or increased pit seepage would be determined through review of monitoring results and trends in conjunction with other relevant information. Evidence of both increased quantity and/or decreased quality of groundwater seepage or existing springs could trigger an agency review of the need for an MPDES permit or permit modification and applicability of Effluent Limitation Guidelines.

Measure W-10, Stipulation 010-13 in the 1998 ROD, would be modified to include additional hydrogeologic studies and monitoring, along with groundwater capture wells east and south as well as west of the pit. Wells installed as a result of these studies would attempt to offset this problem of complying with applicable standards. Existing and additional conceptual monitoring well locations are suggested in this SEIS for bonding purposes (Figure 2-7 and Table 4-8). More wells would be needed due to the uncertainty of hitting groundwater flow paths.

Secure funding and infrastructure are required to collect and treat contaminated water in perpetuity. The principal consequence of failure of this alternative would be undetected or uncaptured discharges of ARD-impacted groundwater from the backfilled pit, which could adversely impact springs and beneficial uses of the Jefferson River alluvial aquifer. In the worst case with no pumping and collection of pit seepage, 16 gpm could reach the Jefferson River alluvial aquifer compared to no discharge assumed in the alternatives that maintain the pit as a hydrologic sink.

4.3.4.2 Impacts to Surface Water Quality and Quantity

4.3.4.2.1 Impacts to Springs, Wetlands

4.3.4.2.1.1 Impacts from Waste Rock Dump Seepage

The impacts to springs and wetlands from waste rock dump seepage would be the same as the No Pit Pond Alternative.

4.3.4.2.1.2 Impacts from Pit Seepage

The 1997 Draft EIS, Chapter IV, Section IV.B.1.b concluded that some spring flows could be reduced because the pit would remain a hydrologic sink. The potential impacts to springs discussed under the No Pit Pond and Partial Pit Backfill With In-Pit Collection alternatives in this SEIS were also primarily related to diminishing spring flows with the pit maintained as a hydrologic sink. Under the Partial Pit Backfill With Downgradient Collection Alternative, the pit would not be maintained as a sink. After approximately 123 years, groundwater in the pit would reach steady state with the surrounding groundwater system at an elevation of 5,260 feet (Telesto, 2003a). Under this alternative, the potential adverse impacts to springs would be related to an increase in quantity of flow and a decrease in water quality. Of the eight bedrock geologic structures identified as possible groundwater flow paths from a saturated pit, six are associated with springs or seeps (see Section 3.3.4, and HSI, 2003). Figure 3-5 shows all the springs around the pit.

Stepan, Stepan Original, Sunlight, Arkose Valley, and Midas springs are situated around the pit and are associated with faults or synclines, or with abandoned mine adits, which are also on geologic structures. Rattlesnake, Bunkhouse and North Borrow springs are situated where discharge from a backfilled pit along the primary flow path could adversely impact the quality and quantity of these springs prior to the point of initial capture in Rattlesnake Gulch. The former Midas Spring is a seasonal discharge that occurs in an active slump area (DEQ and BLM, 1998) and was buried by the East Waste Rock Dump Complex. The source of the spring is uncertain but may originate from the abandoned Midas Adit. It may become acidified within the adit and by contact with waste rock beneath the dump. It is captured and conveyed to treatment.

Some springs, including Rattlesnake, Bunkhouse, Stepan, and Stepan Original are currently slightly to strongly acidic and contain some elevated metal concentrations (Table 3-1). This water quality is due to natural mineralization, but possibly affected by historic underground mining. These springs also have ferricrete deposits, which are indicative of long-term deposition of iron and other minerals by groundwater discharge before mining began in the area (HSI, 2003).

In addition, potential impacts could occur to springs having good water quality located on mineralized structures that may or may not be linked to the pit, including the Sunlight and Arkose Valley springs. These two springs are on the Latite Valley PDZ, a geologic structure that has four of five indicators of a possible groundwater flow path from a saturated pit (HSI, 2003).

The potential impacts to these springs would likely include increased acidity with eventual increased concentrations of dissolved metals, such as aluminum, cadmium, copper, iron, manganese, nickel, zinc, and other constituents, such as sulfate and total dissolved solids. The flows and quality of springs having hydrologic connections to the pit did not noticeably decrease during operations, even with the drought (HSI, 2003). These flows could increase and their water quality decrease somewhat from current levels due to the recovery of groundwater levels and hydraulic head in the pit under this alternative. This alternative is more likely to increase discharges of ARD at existing springs around the pit area, or create new springs or seeps impacted by ARD from the pit, than alternatives that maintain the pit as a hydrologic sink.

There is a reasonable likelihood that, under the Partial Pit Backfill With Downgradient Collection Alternative, one or more existing springs could be adversely impacted by the discharge from a backfilled pit. These potential water quality impacts could trigger an MPDES permitting review by DEQ. There is an additional potential for the creation of new springs or seeps around the backfilled pit in locations where the hydraulic head in the pit is greater relative to the groundwater elevations in possible groundwater pathways from fractures and old mine workings (HSI, 2003). Such new springs would also be subject to an MPDES permitting review by DEQ.

Measure W-1, Stipulation 010-4 in the 1998 ROD, would be modified to monitor for increased discharges from existing springs and seeps and for new springs and seeps. Any change to springs and seeps quantity and/or quality, and their associated source of contaminants, would be subject to an MPDES permitting review by DEQ. For bonding purposes, the agencies have assumed that one existing spring, Stepan Spring, would have a 15 percent increase in flow that would have to be collected and treated, and that one new spring discharging 1.5 gpm would develop and would be collected and treated under an MPDES permit. The assumed flow rate changes are based solely on existing spring information for the area and are strictly assumptions for analysis purposes.

4.3.4.2.2 Risk of Violation of Surface Water Standards and Beneficial Uses of the Jefferson River and Slough

4.3.4.2.2.1 Impacts from Waste Rock Dump Seepage

Impacts from 1 to 3 gpm of seepage from the East Waste Rock Dump Complex in Rattlesnake Gulch under this alternative would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative.

4.3.4.2.2.2 Impacts from Pit Seepage

Pit seepage under this alternative would be more likely to reach the Jefferson River alluvial aquifer and the Jefferson River and Slough. Pit seepage would be allowed to leave the pit and reach the Tdf/colluvial aquifer, where it would be partially captured by two lines of capture wells and other wells on flow paths (Table 4-8). The DSM predicted that an overall 95 percent groundwater capture efficiency would be needed to prevent exceeding groundwater quality standards after mixing with the groundwater of the Jefferson River alluvial aquifer (HSI, 2003). Two groundwater capture systems (Rattlesnake Gulch interception wells and the Tailings Impoundment No. 1 south pumpback system) would be used to try to capture this seepage. The point of control of the pit seepage would be much closer to the Jefferson River alluvial aquifer. There is little attenuation capacity in the Tdf/colluvial aquifer. High capture efficiencies are not guaranteed, as described in Section 4.2.3.1.2. Control of potential pit seepage along secondary pathways is another complication. The risk of contaminants reaching the Jefferson River Slough or Jefferson River is greater than for alternatives that maintain the pit as a hydrologic sink.

4.3.4.3 Reclamation Plan Changes

4.3.4.3.1 Surface Disturbance

Surface disturbance for the Partial Pit Backfill With Downgradient Collection Alternative would be similar to the Partial Pit Backfill With In-Pit Collection Alternative, except 2 additional acres would be disturbed for downgradient collection wells, access roads, pipelines, and powerlines (Table 4-6). The number of acres on 2H:1V slopes requiring coversoil rock amendments under this alternative would be the same as the Partial Pit Backfill With In-Pit Collection Alternative.

4.3.4.3.2 Hazards to Wildlife

Hazards to wildlife under this alternative would be the same as the Partial Pit Backfill With In-Pit Collection Alternative.

4.3.4.3.3 Total Remaining Unrevegetated Acres

There would be no remaining unrevegetated pit acres under this alternative.

4.3.5 Underground Sump Alternative

Under this alternative, the underground workings beneath the pit would be adapted to be used as a sump for removing water from the pit and routing it to the water treatment plant after closure. The design of the underground collection system is discussed in Section 2.4.5.3. The pit would be maintained as a hydrologic sink, similar to the No Pit Pond Alternative and Partial Pit Backfill With In-Pit Collection Alternative. The ultimate pit design would be the same as the other alternatives, except no material would be backfilled into the bottom of the pit. A new portal would be developed at the 4,550-foot elevation to replace the 4,857-foot portal, which will be eliminated during Stage 5B mining. Only rock raveling off the highwall over time and highwall rock from assumed failures would accumulate on the pit bottom, as described in Section 4.2.4.9.1.

Compared to other alternatives, groundwater and precipitation entering the pit would encounter the least amount of acidic rock in the lower pit, which is estimated by the agencies to be 200,000 cubic yards (300,000 tons) over the long term, prior to being captured and sent to treatment. Unlike the No Pit Pond Alternative, a staging area for pumping facilities would not be required inside the pit. Underground access would, however, still need to be maintained. As a contingency against failures, which could destroy the 4,550-foot-elevation portal, the agencies would require GSM to submit a plan for development, maintenance and monitoring of a portal at a suitable alternative elevation. If the 4,550-foot-elevation portal is inaccessible, GSM would have to submit a plan for a secondary escape way and access to the underground workings. Additional details on the design of this alternative may be found in Section 2.4.5.

4.3.5.1 Impacts to Groundwater Quality and Quantity

4.3.5.1.1 Risk of Impacts to Groundwater Quality and Quantity in Permit Area

4.3.5.1.1.1 Impacts from Waste Rock Dump Seepage

Impacts to groundwater resources associated with the East Waste Rock Dump Complex seepage are generally the same as were described for the No Pit Pond Alternative.

This alternative would result in the largest amount of waste rock in the final East Waste Rock Dump Complex. Based on the relative mass of waste rock, the difference between this alternative and the No Pit Pond Alternative is only about 0.1 percent.

4.3.5.1.1.1.1 Long-Term Monitoring and Mitigation for Unanticipated East Waste Rock Dump Complex Seepage

Long-term monitoring and mitigation under this alternative would be the same as the No Pit Pond Alternative and all other alternatives.

4.3.5.1.1.1.2 Summary of East Waste Rock Dump Complex Seepage Impacts to Water Quality and Water Quantity

Impacts to groundwater under this alternative would be essentially the same as the No Pit Pond Alternative and all other alternatives.

4.3.5.1.1.2 Impacts from Pit Seepage

4.3.5.1.1.2.1 Impacts to Water Quality

Water-related impacts from the pit under this alternative would be similar to those for the No Pit Pond Alternative. Since no waste rock would be placed in the pit, groundwater and precipitation entering the pit would have contact with 200,000 cubic yards (300,000 tons) of acid-producing rock.

Water quality in the pit under the Underground Sump Alternative would be similar to the No Pit Pond Alternative. Under the Underground Sump Alternative, pumping regularly would remove pit water from the underground sump and send it to the water treatment plant. The regular pumping would minimize changes in groundwater quality and maintain the pit as a sink, with a cone of depression in the potentiometric surface centered on the pit similar to that which presently exists but 25 to 75 feet deeper. No ARD impacts to groundwater quality outside the pit would be anticipated. If ARD pumped from the pit exceeds the expected rates, mitigation Measure W-6 approved in the 1998 ROD as Stipulation 010-9 would provide for additional water treatment plant capacity to treat the additional flows.

4.3.5.1.1.2.2 Impacts to Water Quantity

A pit water balance model was developed in the 1997 Draft EIS, Table IV-5, which accounted for total inflows and outflows (Hydrometrics 1995). That model found that complete dewatering of the pit to the 4,700-foot pit floor permitted at that time would require removal of approximately 102 gpm.

The revised SEIS water balance model is described under the No Pit Pond Alternative, Section 4.3.2.1. This SEIS model was calibrated to recent pumping records to predict pit dewatering under the Underground Sump Alternative. Average inflow under the Underground Sump Alternative is expected to be the same as that of the No Pit Pond Alternative. Although the pumping level in the underground sump would be 25 to 75 feet deeper than in the No Pit Pond Alternative, the rate of groundwater inflow from the underground workings would be minimal (H. Bogert, GSM, personal communication, 2004).

This SEIS has generally found that the water-related impacts of this alternative would be similar to those predicted in the 1997 Draft EIS, Chapter IV, Section IV.B.6 for the No Pit Pond Alternative, except that the long-term pumping rate from the pit sump is projected to be 32 gpm instead of the 102 gpm predicted in the 1997 Draft EIS.

Potential water resource impacts from the Underground Sump Alternative would be limited to possible additional reductions in the bedrock groundwater level and the flows of springs hydrologically connected to the pit, as a result of the continued pit dewatering. This is an unavoidable impact of maintaining the pit as a hydrologic sink.

4.3.5.1.1.2.3 Summary of Pit Impacts to Water Quality and Quantity

Under this alternative, 32 gpm would be pumped out of the underground sump and treated. Water quality would be similar to that predicted in Table 4-5. Pumping from the underground workings would provide complete control of the predicted pit water discharge. It would be relatively easy to pump from the underground sump as long as access is maintained. The agencies would require a contingency portal location for secondary access to ensure continued pumping and worker safety. As long as access to the underground is maintained, it is relatively easy to repair, replace, and maintain the dewatering system under this alternative. If the predicted pit flows were twice as much as predicted, the dewatering system could easily be upgraded and routed to the water treatment plant. GSM is proposing to test in situ treatment of the water in the underground sump during the 2004-2005 mill shutdown (GSM, 2004). GSM contends that pretreatment of the water in the sump may be possible. It is anticipated that pit water quality would be better under the Underground Sump Alternative than under the partial pit backfill alternatives because of less contact with reactive rock.

4.3.5.1.2 Risk of Violation of Groundwater Standards at Permit Boundary and Impacts to Beneficial Uses of the Jefferson River Alluvial Aquifer

4.3.5.1.2.1 Impacts from Waste Rock Dump Seepage

The impacts from waste rock dump seepage would be the same as under all the other alternatives.

4.3.5.1.2.2 Impacts from Pit Seepage

The pit would be maintained as a hydrologic sink under this alternative with no additional risk to the Jefferson River alluvial aquifer. If ARD from the pit exceeds the expected rates, provisions such as mitigation Measure W-6 approved in the 1998 ROD as Stipulation 010-9 would provide for additional permanent treatment plant capacity to treat the additional flows. No water would migrate toward the Jefferson River alluvial aquifer.

The principal consequence of failure of this alternative would be creation of an ARD-impacted pit pond. In the Pit Pond Alternative, which was dismissed in Section 2.5.4, the water level in the pit would have risen to the 4,635-foot elevation. Under the Underground Sump Alternative, no backfill would be placed in the pit, and the agencies have assumed that 200,000 cubic yards (300,000 tons) of highwall rock would ravel and slough over time. With this volume of rock in the bottom of the pit the water level would rise above the 4,635-foot elevation but stay below the 5,050-foot elevation, which is the elevation at which pit seepage would begin to migrate out of the pit. Since control of water from a pit pond can be accomplished by direct pumping and treating, no adverse impacts to groundwater outside the pit would be anticipated. In addition, water in a pit pond could be more easily pretreated before pumping to the water treatment plant.

4.3.5.2 Impacts to Surface Water Quality and Quantity

4.3.5.2.1 Impacts to Springs, Wetlands

4.3.5.2.1.1 Impacts from Waste Rock Dump Seepage

The impacts to springs and wetlands from waste rock dump seepage would be the same as the No Pit Pond Alternative.

4.3.5.2.1.2 Impacts from Pit Seepage

Under the Underground Sump Alternative, pit water elevations would be maintained within the underground sump, with the pumping level ranging from 4,450 to 4,500-foot elevation. This would be 25 to 75 feet deeper than the water level that would be maintained under the No Pit Pond and Partial Pit Backfill With In-Pit Collection alternatives. Long-term impacts to springs would be similar to those that are predicted under the No Pit Pond Alternative, Section 4.3.2.2.1.2, except that the water table may be further reduced by the 25 to 75 foot deeper cone of depression.

If the groundwater system has not reached equilibrium at the conclusion of mining Stage 5B, long-term impacts to springs from pit dewatering may be somewhat greater than impacts of current operations and predictions from the 1997 Draft EIS and this SEIS. GSM maintains a spring monitoring program, including flow rates and water quality (GSM, 2002a). Continued monitoring and mitigation measures similar to mitigation Measure W-1 approved in the 1998 ROD as Stipulation 010-4, which requires spring flow and water quality monitoring, would be required.

4.3.5.2.2 Risk of Violation of Surface Water Standards and Impacts to Beneficial Uses of the Jefferson River and Slough

4.3.5.2.2.1 Impacts from Waste Rock Dump Seepage

Impacts from waste rock dump seepage on surface water quality and quantity would be the same as under the other alternatives.

4.3.5.2.2.2 Impacts from Pit Seepage

Impacts from pit seepage under this alternative would be the same as the No Pit Pond Alternative, which predicted no impacts to the Jefferson River and Slough in the 1997 Draft EIS and this SEIS.

4.3.5.3 Reclamation Plan Changes

4.3.5.3.1 Surface Disturbance

Surface disturbance for the Underground Sump Alternative would be similar to the No Pit Pond Alternative. About 285,000 cubic yards of stockpiled soil would be used to revegetate the additional 52 acres to be reclaimed (7 acres already reclaimed) of pit disturbance.

4.3.5.3.2 Hazards to Wildlife

Hazards to wildlife under this alternative would be the same as the No Pit Pond Alternative.

4.3.5.3.3 Total Remaining Unrevegetated Acres

About 158 acres of the pit disturbance area would be left unrevegetated.

4.4 SOCIOECONOMIC ISSUES

4.4.1 Introduction

Analyses for this SEIS are based on the assumption that GSM would complete Stage 5B, which should extend operations through 2008 (GSM, 2002a). Selection of a pit closure alternative might directly affect the economics on which future mining decisions are based. Moreover, after this mine has been shut down, the type of pit closure that is implemented could have a continued impact on the prospects for future development of the potential remaining mineral resource.

The proposed action in the 1998 Final EIS provided for mining operations to continue through 2006. No increase in work force was expected. Because GSM was an on-going operation and no new work force was required, no changes were expected with regard to population, housing, schools, water supply, waste water treatment, solid waste disposal, fire protection, law enforcement, health care, or community recreation. Tax revenue and other economic benefits would be discontinued at the end of the mine life at the end of 2006.

For this SEIS, the MAA process took a more detailed look at the socioeconomic issues. This included evaluating issues such as cultural resources, noise, safety, aesthetics, employment opportunities, revenue from taxes, mineral resources/reserves, and future burden on society and the company. MAA accounts under each of these areas were evaluated in detail (Robertson GeoConsultants, 2003).

Initiation of mining the Stage 5B pit in October 2003 has increased mine employment. This addition has been offset by the elimination of contractor personnel at the cessation of the underground operation in January 2004.

4.4.2 No Pit Pond Alternative (No Action)

4.4.2.1 Safety

The topography of the mine area would differ depending on the reclamation alternative that is implemented and would affect safety. The No Pit Pond Alternative has limited backfill, and the pit would be maintained in about the same configuration left by mining. The highwall inside the pit would have cliff-like configurations that would be hazardous. Stability of the highwall could degrade over time producing periodic raveling and sloughing as described in Section 4.2.1.2.2.

4.4.2.1.1 Risk to Workers (Reclamation and Construction)

After Stage 5B is completed, reclamation and construction of the dewatering system would begin. In the 1997 Draft EIS, Chapter IV, Section IV.N.6 under the No Pit Pond

Alternative, in order to provide safe access to the floor of the pit for construction and operation of the dewatering system, the pit would have been partially backfilled with waste rock from the 4,700-foot to the 4,800-foot elevation, creating a flat working surface of 7.4 acres. In this SEIS under the No Pit Pond Alternative, in order to provide safe access to the floor of the pit for construction and operation of the dewatering system, the pit would be partially backfilled with crusher reject from the 4,525-foot to the 4,625-foot elevation (GSM, 2002a).

This partial backfilling of the pit would allow creation of a flat working area of approximately 1.3 acres (300 feet by 225 feet). Although the area is smaller than the area in the 1997 Draft EIS, the pit highwall at this elevation is more stable than envisioned in 1997 due to the pre-split blasting techniques employed. In addition, there would remain a 70-foot-wide safety bench at the 5,700-foot elevation above three sides of the working area for additional protection. Additional protection would be provided by building one or more berms around the perimeter of the working area to trap incidental rocks that may fall from the highwall. The agencies would require the road leading down to the working area from the 4,875-foot elevation to be widened by extending the road to the south, over a portion of the 4,800-foot area, and away from the highwall toe.

Under the No Pit Pond Alternative, trucks loaded with waste rock would have to drive down the 8 to 12-percent-grade pit haul road to deposit backfill in the bottom of the pit. Hauling 111,000 cubic yards (167,000 tons) of crusher reject down the pit haul road would expose drivers to an increased hazard for up to 3 months. Because of this risk, GSM's safety policy would require trucks to be operated partially loaded.

Operating bulldozers to level the backfill and drilling equipment to install the dewatering wells below the pit highwall would expose workers to some risk. Although pit safety benches would be maintained to minimize hazards to workers, operating equipment below unstable areas would be a concern.

The safety risk to reclamation workers under the No Pit Pond Alternative is increased while backfill is being hauled down the steep roads into the pit because the potential for truck accidents would be increased mainly from brake failures. In addition, the workers would be below a highwall of up to 1,875 feet increasing the risk of injury from rock falls.

The Mine Safety and Health Administration (MSHA) tracks mine related injuries and reports national average lost time accident (LTA) rates. These numbers for surface metal mines have ranged from 2.1 to 2.8 LTAs per year in the past 10 years (www.msha.gov). No attempt was made to assign lost time accidents by alternative. The longer reclamation takes, the higher the likelihood of having LTAs or even a death. Under the No Pit Pond Alternative, reclamation would take 23 person years to complete, and total mine reclamation and construction would take about 123 person years to complete.

4.4.2.1.2 Risk to Workers (Long-Term Maintenance)

Under the No Pit Pond Alternative, workers in the pit would be exposed to pit highwall raveling and sloughing hazards from the 1,775-foot highwall. The No Pit Pond Alternative would require long-term access to the pit bottom for monitoring and maintenance of the pit haul road, 5,700-foot-elevation pit safety bench, and the dewatering system.

4.4.2.1.3 Risk to Public Safety

Access restrictions on general public use would be maintained under the No Pit Pond Alternative. Access restrictions would consist of signs, berms, and fencing around the pit area, but there would still be a risk to public safety because of the pit highwall.

4.4.2.2 Mining Employment

4.4.2.2.1 Potential Employment from Mining Stage 5B

The 1997 Draft EIS, Chapter IV, Section J.2.a predicted employment and potential tax revenues for mining the Stage 5 pit. Table 4-9 summarizes employment opportunities and potential tax revenues of the alternatives in this SEIS through the end of Stage 5B compared with the projections from the 1997 Draft EIS.

Table 4 - 9 Total Mining Employment and Economic Benefits of GSM Through Stage 5B

ITEM	1997 Draft EIS Projection (1997-2011)	SEIS Projection (1997-2009)	Current (1997-2003)
Average Number of Employees (1997 thru 2011)	96 (average)	119	132
Salaries	60,111,200	82,918,724	49,335,044
Payroll Taxes	4,872,000	16,583,745	3,620,728
Benefits	11,038,850	33,167,490	12,476,688
Revenue from Taxes Paid (Property, Gross Proceeds, Metals Mine License, State)	21,523,400	19,125,719	12,051,674
Purchases of Goods and Services, Inside and Outside of Montana	386,516,279	367,117,592	186,117,592
Total	484,061,729	518,913,270	251,550,052

Under the No Pit Pond Alternative, GSM would be expected to complete mining and reclamation tasks within a period of 10 years. The continued operation of the mine under Stage 5B would provide for on-going employment of mine personnel. No new work force would be expected from current levels. No new changes induced by the project are anticipated with respect to population, housing, schools, water supply, wastewater treatment, solid waste disposal, fire protection, law enforcement, health care, or community recreation.

Since 1983 when major mining development was initiated at GSM, employment has ranged from 74 to 301 employees. As of June 2004, GSM employed a total of 130 persons with an additional 33 contractor personnel. During mill shutdown in 2004-2005 and initial waste rock stripping for Stage 5B, GSM employment will remain at this level (GSM 2003 annual report). The employment level will be reduced after the 16 to 18 months of Stage 5B waste rock stripping. GSM has maintained a policy of hiring from the local area when possible since inception of operations. The number of employees needed to complete Stage 5B mining would vary by year. There is also a multiplier effect for secondary employment opportunities. This effect results in other indirect employment opportunities.

Upon completion of Stage 5B mining and mine closure under all alternatives, there would be an immediate staff reduction. When employment terminates, workers would find other jobs locally or relocate, depending on job availability. Workers remaining in the area would continue to make demands on community services and could increase the demand on assistance programs.

The community of Whitehall would experience impacts from closure of the mine. Typically, approximately 65 percent of the GSM workforce resides in the Whitehall area. It is estimated that as of June 2004, 10 percent of the town's population is employed full time at the mine (104 people out of a population of 1,044). If a typical family of three is assumed, approximately 30 percent of the population would be estimated to be dependent on GSM employment. In addition, mining jobs support secondary employment in the services sector and other industries (Table 4-9).

The anticipated mining employment opportunities from mining Stage 5B under the No Pit Pond Alternative are 750 person years.

4.4.2.3 Reclamation Employment

4.4.2.3.1 Reclamation Employment Opportunities

After mining ceases, a reduced labor force would be employed for a period of up to 3 years to complete reclamation and to prepare the site for long-term water treatment. About 2 years would be required to decommission the facilities, place 100 feet of crusher reject in the pit bottom, and reclaim other disturbed areas. The predicted employment opportunities during reclamation under the No Pit Pond Alternative are 123 person years. Only about 23 person years of this total would be attributable to pit closure tasks. Following pit closure, dewatering and water treatment would continue indefinitely, requiring a full time staff of less than ten. Reclamation would end about

2010. After reclamation is complete, continued employment would occur at a reduced level to maintain the site and operate the dewatering and water treatment systems. Under the No Pit Pond Alternative, about two to five employees would be needed indefinitely.

4.4.2.4 Revenue from Taxes

4.4.2.4.1 Potential Tax Revenues from Mining Stage 5B

Estimates of tax revenue were made for the completion of mining of Stage 5B, which included property tax, metalliferous mines license tax, gross proceeds tax, and state payroll tax. No federal taxes were included. Payroll tax was estimated on averages for employee salaries for the number of person years estimated for the mining employment section above. The estimated tax revenue from Stage 5B mining under the No Pit Pond Alternative would be $8,087,000.

In 2002, GSM paid $821,866 in metal mine license tax, $492,362 in gross proceeds tax, and $309,232 in other property taxes. The total tax payment was $1,623,460.

In 2003, GSM paid $1,217,076 in metal mine license tax, $412,675 in gross proceeds tax, and $215,115 in other property taxes. The total tax payment was $1,844,866. Comparable tax payments would be expected during the years that Stage 5B is mined, except during the waste rock stripping when no gold is produced.

The socioeconomic impacts from closure and reclamation would be the loss of tax payments. Taxes based on production would end with the completion of mineral processing. Property taxes would gradually decrease with the decommissioning of facilities, but would be maintained indefinitely at some level on the land and the dewatering and water treatment system.

4.4.2.4.2 Potential Tax Revenues from Pit Backfill

After Stage 5B mining is completed, the only taxes paid by GSM during reclamation would be property taxes. Estimates of potential tax revenue for reclamation activities include property tax and state payroll tax. No federal taxes were included. The estimated tax revenue from reclamation under the No Pit Pond Alternative would be $319,500.

4.4.2.5 Mineral Reserves and Resources

4.4.2.5.1 Access to Future Mineral Reserves/Resources

GSM contends that precious metal mineralization extends beyond the planned limits of the open pit floor and highwall for Stage 5B (GSM, 2002a). Stage 5B mining would contribute approximately 500,000 ounces if completed. GSM contends that there are over 1,500,000 ounces remaining in the known resource (GSM, personal communication, 2003). There might be additional resources that have not been identified by exploration activities. The minerals may not be considered feasible to mine under current economic conditions and technology. Changes in external conditions, such as fluctuating metals prices and improvements in technology, may result in revised open pit designs, which could increase the amount of economically extractable ore some time in the future. GSM contends that if these resources are buried due to backfilling requirements, the cost of recovering them in the future may be so high that the resource would be unavailable. Although it is technically possible to remove the backfill material, it may not be economically feasible to remove the remaining gold.

A mineral resource is defined as a concentration or occurrence of natural, solid, and inorganic material in or on the earth's crust in such form and quantity and of such grade or quality that it has reasonable prospects for economic extraction. The definitions utilized by Placer Dome for reporting conform to Canadian Institute of Mining, Metallurgy and Petroleum definition of these terms as of the effective date of estimation, as required by National Instrument 43-101 of the Canadian Securities Administrators.

One of the purposes of MMRA is to prevent foreclosure of future access to mineral resources not fully developed by current mining operations (82-4-302(1)(f), MCA). However, MMRA does not direct DEQ to adopt pit reclamation alternatives that would allow future access to unmined reserves. The degree of future accessibility of the remaining gold bearing mineralization would in part determine the future mining potential for the remainder of the resource. That accessibility would be influenced by the pit reclamation plan chosen.

Three factors of the pit reclamation plan that could affect future mining potential include:

- Amount of backfill placed in the pit;
- Amount of highwall rock that would ravel and slough into the pit over time; and
- Ability to dewater the saturated portion of the backfill.

Under the No Pit Pond Alternative, the pit would be backfilled from 4,525 to 4,625 feet. About 111,000 cubic yards (167,000 tons) of backfill and 290,400 cubic yards of soil would have to be removed from 60 acres if the pit were enlarged for additional mining in the future. In addition, as described in Section 4.2.1.2.2, the agencies have assumed some highwall rock is expected to ravel and slough into the pit over time, some of which would have to be removed.

The agencies have assumed 100,000 cubic yards (150,000 tons) of highwall rock would ravel over time. In addition, another 100,000 cubic yards would slough into the pit as a mass failure of the highwall, which would bury the dewatering system. GSM would have to re-establish the 5,700-foot safety bench for access and safety. This would produce an unknown volume of highwall rock. GSM would have to haul more backfill into the pit to create a new flat working surface and reestablish the dewatering system wells. As a result, the agencies have assumed soil cover and 200 feet of highwall rock and backfill or a minimum of 600,000 cubic yards would have to be removed before mining could begin again.

The pit would have to be dewatered before enlarging the pit in the future. The dewatering system needed to dry out the saturated backfill would already be in place, but may be destroyed as the mine is expanded. Because only the bottom 200 feet of the pit would be filled with waste rock, the time required to dewater the pit for continued mining would be less than the partial pit backfill alternatives. During 2002 mining, an average of 405,333 cubic yards (608,000 tons) of waste rock and ore was removed from the bottom of the pit per month. Assuming a similar mining rate, it would take 1.5 months to remove 600,000 cubic yards.

Because of the limited amount of rock that would have to be removed, the waste-to-ore ratio would not increase substantially. In addition, the time required to dewater the pit would be minimal. This alternative would have a limited impact on future recovery of mineral resources. Under this alternative, the potential would remain for continued exploration and possible future mining with minimal implementation problems.

4.4.2.6 Land Use After Mining

4.4.2.6.1 Suitability of Land Use after Mining

Land uses of the permit area before mining consisted of wildlife habitat, livestock grazing, agriculture, timber, recreation, and industrial use, as discussed in Section 3.8. Within the area of the open pit, the steep terrain limited activities such as livestock grazing and precluded other agriculture land uses. So, prior to construction of the open pit mine, this area was used for wildlife habitat, limited livestock grazing, and mining. Because timber is sparse in this area, timber harvesting has not been impacted. The only recreation activities that likely could have occurred in the area in the past were hunting and hiking, which were dependent on the permission of the previous owner.

Land use after mining was judged in terms of the suitability of the alternative to achieve that land use. In all cases, that land use would be a reclaimed mine with on-going monitoring, maintenance, water treatment, and wildlife habitat. Under the No Pit Pond Alternative, 60 acres in the pit would be revegetated as mule deer habitat, and 158 acres would be reclaimed as highwall. GSM would also develop a small portion of the highwall in the pit to provide bat and raptor habitat on the upper oxidized highwall, as described and evaluated in the 1997 Draft EIS, Chapter IV, Section IV.E and described in this SEIS in Section 2.4.2.6.

Under the No Pit Pond Alternative, additional disturbance of lands would not occur. The pit area would be maintained as a hydrologic sink with the pit bottom being used to capture and collect contaminated water. A fence, signs, and berms would be constructed around the open pit to preclude large mammals including humans from entering the area. The industrial usage at the bottom of the pit and the fence would not preclude bats and raptors from using the upper oxidized pit highwall and mule deer from using the revegetated areas within the pit.

Approximately 5 acres of existing disturbance would be used for the dewatering system and access roads in the pit. Hunting and other recreational activities around the pit and in other operational areas would be prohibited. The primary land use impact under this alternative would be the permanent loss of 158 acres of wildlife habitat.

4.4.2.7 Aesthetics

Visual resources impacts were evaluated in the 1997 Draft EIS, Chapter IV, Section IV.I.

4.4.2.7.1 Visual Contrast With Adjacent Lands

The impact the No Pit Pond Alternative would have on visual resources was evaluated in the 1997 Draft EIS, Section IV.I. It was determined that for the pit under this alternative, visual contrasts would be reduced to a level where they would be noticeable but not dominant in the landscape, following successful reclamation and revegetation. Landscape modifications for the area would be consistent with a Class III rating according to the BLM's visual resource management system.

A high degree of visual contrast would relate to a poor aesthetic value. As stated in MMRA with regard to open pits and rock faces, the reclamation plan must provide sufficient measures for reclamation to a condition that mitigates visual contrasts between reclamation lands and adjacent lands.

Since the 1997 Draft EIS evaluation, the design of the pit highwall and the scope of the proposed reclamation plans have changed with respect to this issue. The one notable change in the pit design is the elevation at which the haul road enters the pit at the low point on the pit rim. The plan was to cut a 32-acre notch out of this section of the pit highwall and lower the road by 150 feet. The existing configuration eliminates the need for the notch and hides more of the pit from view from all vantage points below the pit rim.

Recontouring and revegetating portions of the pit would reduce the visual contrast with adjacent undisturbed lands. GSM has proposed to revegetate 60 acres in the 218-acre pit, of which 15 acres would be visible. The measures that would be used to reduce visual contrast under the No Pit Pond Alternative include planting trees around the pit perimeter where possible, and where safety allows, seeding and planting trees on final oxidized benches containing enough fine material to support plant life (GSM, 2002). The raveling and sloughing of pit highwalls over time would reduce visual contrast.

To further reduce visual contrast, the agencies would require GSM to treat additional safely accessible areas in the pit above the 5,700-foot safety bench (see Section 4.8.3.2). The agencies would also require GSM to extend the East Waste Rock Dump

Complex across the mouth of the pit to tie into the natural slope and partially screen the view of the highwall (see Section 4.8.3.2).

4.4.2.8 Potential Future Burden

4.4.2.8.1 Potential Future Burden on Society

Operation and maintenance of reclaimed mines involves infrastructure used to collect, treat and release the impacted water, divert clean water, and maintain covers, etc. Over time, some facilities would need to be upgraded, rebuilt or replaced. Monitoring programs would be required. While all activities after mining would be the responsibility of GSM and would be bonded, site management may become the responsibility of another private or agency custodian. The long-term nature of these requirements at GSM suggests a risk to society to inherit the burden if the responsible party fails in its obligations.

The complexity of the dewatering and water collection systems and the uncertainty of collecting all pit water would be the largest potential burden on society under any alternative. Under the No Pit Pond Alternative, these systems for the pit area would consist of two to three 100-foot-deep wells, a power line, and a pipeline to the water treatment plant. The agencies have assumed a pit highwall failure over time which would increase the depth of the wells needed to 200 feet.

The principal consequence of failure of long-term implementation of the No Pit Pond Alternative would be creation of an ARD-impacted pit pond below the 5,050-foot elevation, as described in Section 4.2.1.9.2. Below this elevation, the water would not flow out of the pit. No impacts to groundwater outside the pit would be anticipated. The risk of this alternative to create a future burden on society is low because water resource impacts to seeps and springs would be minimal. Beneficial uses of the Jefferson River alluvial aquifer would not be impacted, as described in Section 4.3.2.1.2.2.

In addition, future treatment technologies could easily be implemented. Pit water would be completely controlled.

4.4.2.8.2 Potential for Future Liabilities for GSM

The complexity of the alternative pit reclamation plan could affect GSM's ability to comply with the operating permit requirements and water quality standards. Liabilities from the alternatives would be based on the potential for water quality degradation related to the amount of backfill, complexity of the dewatering system, and continued access to the dewatering system for operation and maintenance.

Under the No Pit Pond Alternative in both the 1997 Draft EIS and this SEIS, there would be no water quality degradation outside of the pit. The water level, even with backfill and pit highwall rock that has raveled and sloughed to the pit bottom over time, would not reach the 5,050-foot elevation. Therefore, no untreated water would leave the pit. In addition, if the dewatering system failed for any reason, it could be re-established on the regraded pit bottom through the agency-assumed ultimate depth of 200 feet of backfill and highwall rock more easily than under an alternative with up to 875 feet of backfill. Continued safe access to the dewatering system for operation and maintenance under the No Pit Pond Alternative would be more difficult than the partial pit backfill alternatives because of highwall rock raveling and sloughing onto access roads and the changing condition of the roads. Removing water from the backfill would be easier because of the agency-assumed 600,000-cubic-yard volume of material from which the water would be pumped and the depth of the wells in the 200 feet of rock in the pit bottom. GSM contends it could comply with groundwater quality standards under the No Pit Pond Alternative (GSM, personal communications, 2003).

4.4.3 Partial Pit Backfill With In-Pit Collection Alternative (Proposed Action)

4.4.3.1 Safety

4.4.3.1.1 Risk to Workers (Reclamation and Construction)

The Partial Pit Backfill With In-Pit Collection Alternative would backfill the pit to a free-draining elevation of 5,350 feet and would reduce all of the pit highwall above this elevation to 2H:1V slopes. All of the 254 pit acres would be covered with 3 feet of soil and revegetated (Table 4-6).

Risk to workers could arise from a number of activities.

- Hauling 111,000 cubic yards (167,000 tons) of crusher reject to the bottom of the pit for the sump under the Partial Pit Backfill With In-Pit Collection Alternative would be the same as for the No Pit Pond Alternative.
- Hauling and end dumping 33,200,000 cubic yards (50,000,000 tons) of material from the edge of the pit that is hundreds of feet deep would expose drivers to limited hazards for 50 to 80 months. This activity is similar to end dumping used to create the waste rock dump complexes.
- Drilling and cast blasting 11,900,000 cubic yards (17,900,000 tons) of pit highwall and dozing blasted materials down to create 2H:1V slopes would expose workers to fall and rollover hazards for about 30 to 36 months.
- Constructing roads on steep slopes and hauling soil along narrow benches and spreading soil on long 2H:1V slopes would expose workers to hazards for 10 to 12 months.

The safety risk to reclamation workers would be the same as under the No Pit Pond Alternative while 100 feet of crusher reject is being hauled down the steep roads into the pit because of the potential for truck accidents especially from brake failures. After placement of the sump material to the 4,625-foot elevation, pit backfilling to the average elevation of 5,400 feet would be accomplished by end dumping waste rock from the pit rim. This is the standard method used during mining to create waste rock dumps and has less risk than hauling loaded trucks to the bottom of the pit.

Cast blasting and dozing would be used to reduce the pit highwall to a 2H:1V slope above the 5,400-foot elevation. Operating bulldozers to create the final slopes would have risk similar to that of reducing the slopes of waste rock dumps. All of the highwall would be eliminated. Workers installing, operating, and maintaining the dewatering system would not be working in a pit below a 1,775-foot highwall and would not be at risk of injury from rock falls.

Pit reclamation would take 108 person years. Total reclamation and construction would take about 308 person years to complete.

4.4.3.1.2 Risk to Workers (Long-Term Maintenance)

Under the Partial Pit Backfill With In-Pit Collection Alternative, long-term access to the pit bottom would not be required. Worker safety over the long term relates primarily to monitoring and maintenance of the reclaimed pit slopes and benches and the dewatering system. The risk to worker safety in this alternative would be less than the No Pit Pond Alternative and would be similar to work currently conducted on the reclaimed portions of the waste rock dump complexes.

4.4.3.1.3 Risk to Public Safety

Access restrictions on general public use would be maintained under the Partial Pit Backfill With In-Pit Collection Alternative. Access restrictions would consist of signs, berms, and fences, and there would be less risk to public safety because the pit highwall would be eliminated.

4.4.3.2 Mining Employment

4.4.3.2.1 Potential Employment from Mining Stage 5B

Impacts associated with mine operation under the Partial Pit Backfill With In-Pit Collection Alternative would be the continued economic benefits of employment and income provided by the mine and county and state tax revenues throughout the mine's projected life span to 2008. The anticipated mining employment opportunities from mining Stage 5B under the Partial Pit Backfill With In-Pit Collection Alternative would be 750 person years.

GSM has indicated that it may not be able to continue mining if a partial pit backfill alternative is selected (GSM, 2002a). Manpower requirements fluctuate on a routine basis during mining. Under this alternative, for each year lost by premature mine closure, mining employment would be reduced by approximately 150 person years, depending on the state of mining. There would be a loss of GSM's 139 full time and 42 contract jobs under this alternative, if mining ceased in September 2004 (GSM, personal communication, September 2004).

4.4.3.3 Reclamation Employment

4.4.3.3.1 Reclamation Employment Opportunities

At the termination of mining, whether it occurs in 2005 or 2008, decommissioning of the facilities, partial backfilling of the pit, and reclamation of other disturbed areas would require an additional 3 years. The predicted employment opportunities during reclamation under the Partial Pit Backfill With In-Pit Collection Alternative would be 308 person years. About 108 person years of this total would be attributable to pit closure tasks. Following pit closure, dewatering and water treatment would continue indefinitely requiring a full time staff of approximately ten. Periodic requirements to repair settling and erosion damage, as well as repair and replace dewatering wells, would provide opportunities for other area service providers.

4.4.3.4 Revenue from Taxes

4.4.3.4.1 Potential Tax Revenues from Mining Stage 5B

The tax revenues from completing Stage 5B would be $8,087,000, the same as the No Pit Pond Alternative. GSM has indicated that mining may cease if partial pit backfilling is required. Under this alternative, for each year lost by premature mine closure, tax revenues would be reduced by $1,605,400. If GSM closes, property tax revenue would be $12,000 per year.

4.4.3.4.2 Potential Tax Revenues from Pit Backfill

Estimates of potential tax revenue for reclamation activities, primarily backfilling, include property tax and state payroll tax totaling $806,000 over a 3-year period. No federal taxes were included.

4.4.3.5 Mineral Reserves and Resources

4.4.3.5.1 Access to Future Mineral Reserves/Resources

Under the Partial Pit Backfill With In-Pit Collection Alternative, the pit would be backfilled from 4,525 feet to an average depth of 5,400 feet. A total of 111,000 cubic yards (167,000 tons) of sump material, 33,200,000 cubic yards (50,000,000 tons) of backfill, 11,900,000 cubic yards (17,900,000 tons) of waste rock covering the highwall, and 1,541,800 cubic yards of soil would have to be removed from 274 acres if the pit was enlarged in the future.

The pit would have to be dewatered while removing the backfill and enlarging the pit in the future. The dewatering system needed to dry out the saturated sump material would already be in place but would be destroyed while removing the backfill. The new dewatering system would have to be implemented in stages as part of the expanded mining operations as is done for regular mining operations below the water table. It is expected the time required to dewater the pit would be longer than the No Pit Pond Alternative. Dewatering a pit backfilled with weathered waste rock could be as difficult as dewatering solid rock because of the amount of fine, cemented material in the weathered waste rock backfill. When the East Waste Rock Dump Complex was partially off-loaded after the 1994 ground movement, the waste rock had weathered into finer material. Ripping of the unsaturated waste rock was needed because of cementation and compaction (Herasymuik, 1996). GSM reported that some of the material required blasting. The agencies have assumed the same process would occur in the backfilled pit.

In order to re-open the pit after reclamation is completed under the Partial Pit Backfill With In-Pit Collection Alternative, a mining company would have to remove 47,000,000 cubic yards of backfill and soil, which includes the amount needed to re-establish the 5,700-foot pit safety bench and to gain access to mineralization below the former pit floor.

Because this amount of rock and soil would have to be removed, this alternative would increase the waste-to-ore strip ratio more than the No Pit Pond Alternative. This would affect the potential for future mining activity more than the No Pit Pond Alternative. Under this alternative, the potential for continued exploration and possible future mining could be limited. The backfill would not be as difficult to remove as solid rock. Assuming a mining rate similar to that used by GSM in 2002, removal of this volume of material could take about 10 years at 405,000 cubic yards per month. Part of the backfill material would be wet, including areas near preferential flow from seeps into the pit. During the years of backfill removal, more could saturate and removal could be more difficult.

4.4.3.6 Land Use After Mining

4.4.3.6.1 Suitability of Land Use After Mining

Under the Partial Pit Backfill With In-Pit Collection Alternative, nearly the entire pit area would be reclaimed to its primary pre-mining land use as wildlife habitat. This alternative would require the disturbance of an additional 56 acres of land on the steep hillsides around the perimeter of the pit from cast blasting and constructing haul roads to haul soil (Figure 2-4). The additional disturbance would be revegetated within a period of about 3 years. The goal of the reclamation plan for the pit disturbance area would be to establish a sustainable plant cover in all areas.

Approximately 1 to 2 acres would be required for the dewatering system and access roads in the reclaimed pit area and would have little utility as wildlife habitat. All other areas would be available for wildlife habitat. Due to the presence of maintenance personnel and equipment in the pit, hunting would be prohibited in most areas. With removal of pit hazards, recreational activities outside the pit, such as hiking, and hunting could be permitted.

Under the Partial Pit Backfill With In-Pit Collection Alternative, 274 acres would be revegetated as mule deer habitat, and no acres would be reclaimed as highwall. GSM would not develop raptor and bat habitat on the upper highwall because there would be no highwall.

4.4.3.7 Aesthetics

4.4.3.7.1 Visual Contrast with Adjacent Lands

The 1997 Draft EIS, Chapter IV, Section IV.I evaluated the impact the Partial Backfill Alternative would have on aesthetics. It was determined that backfilling the pit to a daylight level and revegetating the upper pit slopes would partially restore the pit area and would decrease the contrasting forms, lines, and colors of the pit benches and highwall visible from key observation points. In addition, hauling waste rock material from the East Waste Rock Dump Complex to backfill the pit would reduce the height of some of the benches in the dump.

In this SEIS the Partial Pit Backfill With In-Pit Collection Alternative would be similar to the Partial Backfill Alternative in the 1997 Draft EIS. The reclaimed 2H:1V slopes covering the pit highwall and the reclaimed slopes of the waste rock dump complexes would still be visible, but the overall contrasts would be reduced under this alternative.

4.4.3.8 Potential Future Burden

4.4.3.8.1 Potential Future Burden on Society

The complexity of the dewatering and water collection systems and the uncertainty of collecting all pit water would be the largest potential burden on society. Under the Partial Pit Backfill With In-Pit Collection Alternative, these systems would consist of four wells up to 875 feet deep, an access road, a powerline, and a pipeline to the water treatment plant.

Funding and infrastructure are required to collect and treat contaminated water after closure. The consequence of failure of this alternative due to technical or financial reasons is uncontrolled discharges of ARD-impacted groundwater from the backfilled pit, which could adversely impact springs (Section 4.3.4.2.1.2) and beneficial uses of the Jefferson River alluvial aquifer, as described in Section 4.3.4.1.2 for the Partial Pit Backfill With Downgradient Collection Alternative. Downgradient capture wells as described in Section 4.2.3.5.1 the Partial Pit Backfill With Downgradient Collection Alternative would be needed as a contingency if the dewatering system failed. Unlike the No Pit Pond Alternative, if implementation of the dewatering system failed, an estimated 16 gpm of seepage would leave the pit and migrate into the regional groundwater system, as described in Section 4.3.4.1.2.2.1 for the Partial Pit Backfill With Downgradient Collection Alternative.

4.4.3.8.2 Potential for Future Liabilities for GSM

Under the Partial Pit Backfill With In-Pit Collection Alternative, the potential for water quality degradation outside of the pit would be increased if the dewatering system failed. The water table would be kept as close as possible to the 4,525-foot elevation by pumping. Untreated water escaping the pit would be the same as under the No Pit

Pond Alternative. If the dewatering system failed due to backfill settling and damage to a well, it could be re-established by drilling a new well in the deeper backfill and replacing the pump. Completion of these wells may be problematic. Safe access to the dewatering system for operation and maintenance would not be a problem because there would be no pit or highwall.

Removing water from up to 875 feet of backfill would be more difficult because of the 47,000,000 cubic yards of backfill material from which the water would be pumped and the 875-foot depth of the wells. Pumps and other dewatering system components would fail regularly from backfill settling and corrosion, as described in Section 4.2.1.5.2. GSM contends that this alternative would create a larger liability for the company in the future because of the uncertainty of pit water quality and complete collection of the water in the pit (GSM, 2002a).

4.4.4 Partial Pit Backfill With Downgradient Collection Alternative

The socioeconomic impacts of the Partial Pit Backfill With Downgradient Collection Alternative are nearly identical to those of the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.1 Safety

4.4.4.1.1 Risk to Workers (Reclamation and Construction)

Under the Partial Pit Backfill With Downgradient Collection Alternative, separate placement of sump material in the bottom of the pit would not be required. All pit backfilling to the average elevation of 5,400 feet would be accomplished by hauling and end dumping waste rock from the East Waste Rock Dump Complex from the pit rim. This is the standard method used during mining to create waste rock dumps and has less risk than hauling loaded trucks to the bottom of the pit.

The pit highwall would be reduced to a 2H:1V slope above the 5,400-foot elevation as described in the Partial Pit Backfill With In-Pit Collection Alternative and the risk to worker safety would be the same. Dewatering wells and collection facilities would be constructed outside the perimeter of the backfilled pit. This would be safer for maintenance workers after mining. Reclamation and construction activities would be the same as the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.1.2 Risk to Workers (Long-Term Maintenance)

Under the Partial Pit Backfill With Downgradient Collection Alternative long-term access to the pit bottom would not be required. Worker safety over the long term relates primarily to monitoring and maintenance of the reclaimed pit slopes and benches and the dewatering system. The risk to worker safety in this alternative would be less than the No Pit Pond Alternative and essentially similar to the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.1.3 Risk to Public Safety

Access restrictions and risk to public safety would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.2 Mining Employment

4.4.4.2.1 Potential Employment from Mining Stage 5B

Employment and income impacts associated with mine operation under the Partial Pit Backfill With Downgradient Collection Alternative would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.3 Reclamation Employment

4.4.4.3.1 Reclamation Employment Opportunities

Employment and income impacts associated with pit reclamation under the Partial Pit Backfill With Downgradient Collection Alternative would be essentially the same as under the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.4 Revenue from Taxes

4.4.4.4.1 Potential Tax Revenues from Mining Stage 5B

Revenue from taxes associated with mine operations under the Partial Pit Backfill With Downgradient Collection Alternative would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.4.2 Potential Tax Revenues from Pit Backfill

Revenue from taxes associated with pit reclamation under the Partial Pit Backfill With Downgradient Collection Alternative would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.5 Mineral Reserves and Resources

4.4.4.5.1 Access to Future Mineral Reserves/Resources

Access to future mineral reserves and resources under the Partial Pit Backfill With Downgradient Collection Alternative would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative. This alternative has an additional impact on access to future mineral reserves and resources compared to the Partial Pit Backfill With In-Pit Collection Alternative. In the Partial Pit Backfill With Downgradient Collection Alternative, the backfill would not be dewatered and the water table would rebound. More of the backfill would have to be dewatered as mining proceeds as described in the Partial Pit Backfill With In-Pit Collection Alternative. The agencies assume that a similar dewatering system as used in the Partial Pit Backfill With In-Pit Collection Alternative would have to be constructed to reverse this alternative. Since there would be no sump material in the bottom of the pit, the dewatering might be less effective. Because there would be no previous dewatering activities, the time required to install the dewatering system and dewater the pit may be longer than the Partial Pit Backfill With In-Pit Collection Alternative. In addition, it may be harder to dewater backfilled, weathered waste rock than the original pit rock.

In order to re-open the pit after reclamation is completed under the Partial Pit Backfill With Downgradient Collection Alternative, a mining company would have to remove 47,000,000 cubic yards of backfill and soil, which includes the amount needed to reestablish pit benches for access and safety. This would increase the waste-to-ore strip ratio. Up to 735 feet of the backfill would be saturated.

4.4.4.6 Land Use After Mining

4.4.4.6.1 Suitability of Land Use After Mining

The suitability of land use after mining under the Partial Pit Backfill With Downgradient Collection Alternative would be essentially the same as under the Partial Pit Backfill With In-Pit Collection Alternative. Collection of contaminated water outside the pit area would require a large number of wells and a more complex collection and conveyance system. This would increase the size of the industrial usage area by 2 acres. In addition, seeps of poor quality water could develop in the area between the pit and the capture wells. The agencies have assumed one new seep would develop as described in Section 4.3.4.2.1.2. The presence of poor quality water and the spread-out nature of the industrial usage areas could impact wildlife usage. Mine operations have had minimal impact on mule deer.

4.4.4.7 Aesthetics

4.4.4.7.1 Visual Contrast with Adjacent Lands

Impacts to visual resources would be the same as the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.8 Potential Future Burden

4.4.4.8.1 Potential Future Burden on Society

The complexity of the dewatering and water collection systems and the uncertainty of collecting all pit water would be the largest potential burden on society. Under the Partial Pit Backfill With Downgradient Collection Alternative, these systems would consist of at least 26 capture wells and at least 10 monitoring wells of various depths and multiple pipelines to the water treatment plant. More wells may be needed based on hydrogeologic studies.

Secure funding and infrastructure are required to collect and treat contaminated water in perpetuity. The principal consequence of failure of this alternative would be undetected or uncaptured discharges of ARD-impacted groundwater from the backfilled pit, which could adversely impact springs and beneficial uses of the Jefferson River alluvial aquifer. Total pit seepage of 16 gpm would reach the regional groundwater system compared to 0 gpm in the alternatives that maintain the pit as a hydrologic sink. Ninety-five percent of the seepage would have to be collected to prevent water quality impacts at the mixing zone boundary, as described in Section 4.3.4.2.2. Ninety-five percent capture efficiency may not be achievable, as described in Section 4.2.3.1.2.

4.4.4.8.2 Potential for Future Liabilities for GSM

Under the Partial Pit Backfill With Downgradient Collection Alternative, the potential for water quality degradation outside of the pit would be increased. The water table would not be kept below the 5,260-foot elevation equilibrium level by pumping. Therefore, 16 gpm of untreated water would escape the pit. Multiple wells would be located down gradient of the pit area to try to capture contaminated groundwater leaving the pit. If the dewatering system failed to capture all of the groundwater, groundwater standards for some constituents would be exceeded at the edge of the mixing zone (Telesto, 2003e).

The agencies assume the quality of the water collected down gradient of the pit would be partially attenuated and mixed with regional groundwater. Pumps and other dewatering system components would not fail as regularly due to settling and corrosion. Scaling and biofouling could increase because the water would be collected down gradient of the pit and have a higher pH. Experience at GSM has shown this not to be a problem. Complete capture of pit seepage would not be possible. Ninety-five percent capture efficiency may not be achievable, as described in Section 4.2.3.1.2. GSM contends that this is the alternative with the most liability in the future (GSM, 2002a). GSM does not agree that ARD should be allowed to escape the pit if it can be prevented, especially if it could violate laws (GSM, personal communication, 2003).

4.4.5 Underground Sump Alternative

The socioeconomic impacts of the Underground Sump Alternative are nearly identical to those of the No Pit Pond Alternative. The principal difference is that pit closure would be confined to reestablishing access, adapting the underground workings, and preparing the underground sump.

4.4.5.1 Safety

4.4.5.1.1 Risk to Workers (Reclamation and Construction)

The Underground Sump Alternative would have less potential for safety liabilities as the No Pit Pond Alternative as it requires workers to maintain access into the pit and to the 4,550-foot-elevation portal as well as maintaining the underground workings. Most dewatering equipment would be stationed inside the underground workings. Rock hazards in the underground workings would be added to the risk from highwall rock hazards. However, the agencies agree that the risk of working on the pit floor would be greater than the risk of working in the underground workings.

Underground mining ceased in January 2004. The lowest stope in the underground workings would be used as a sump in the dewatering system for Stage 5B. During Stage 5B most of the underground workings would be mined out. After Stage 5B is completed, access to the underground workings would be reestablished by developing a portal at the 4,550-foot elevation. The current operational dewatering system in the underground workings would be redesigned for long-term use as described in Section 2.4.5.3. Under the Underground Sump Alternative, workers would re-enter the underground workings to evaluate wall and ceiling stability. Dewatering system construction workers would be exposed to rock falls from the walls and ceiling. Wall and ceiling stability would be monitored and repairs made as needed to ensure worker safety and the integrity of the dewatering system. The agencies would require GSM to develop a long-term plan to stabilize and maintain the ceiling and walls of the underground workings, especially the stopes.

Pit reclamation and construction under the Underground Sump Alternative would take 24 person years and complete mine reclamation would take about 124 person years.

4.4.5.1.2 Risk to Workers (Long-Term Maintenance)

Risk to worker safety over the long term would be less than the No Pit Pond Alternative. The risks of working underground are less than the risks of working in the bottom of the pit.

4.4.5.1.3 Risk to Public Safety

Access restrictions to the pit area on general public use would be the same as under the No Pit Pond Alternative.

4.4.5.2 Mining Employment

4.4.5.2.1 Potential Employment from Mining Stage 5B

Employment and income impacts associated with mine operation under the Underground Sump Alternative would be the same as under the No Pit Pond Alternative.

4.4.5.3 Reclamation Employment

4.4.5.3.1 Reclamation Employment Opportunities

Employment and income impacts associated with pit reclamation under the Underground Sump Alternative would be essentially the same as under the No Pit Pond Alternative.

4.4.5.4 Revenue from Taxes

4.4.5.4.1 Potential Tax Revenues from Mining Stage 5B

Revenue from taxes associated with mine operation under the Underground Sump Alternative would be the same as under the No Pit Pond Alternative.

4.4.5.4.2 Potential Tax Revenues from Pit Backfill

Revenue from taxes associated with pit reclamation under the Underground Sump Alternative would be essentially the same as under the No Pit Pond Alternative.

4.4.5.5 Mineral Reserves and Resources

4.4.5.5.1 Access to Future Mineral Reserves/Resources

Under the Underground Sump Alternative, no backfill would be placed in the pit. The 200,000 cubic yards (300,000 tons) of pit highwall rock that would ravel or slough over time would have to be removed as part of the future mining plan. The pit bottom would remain dry except after precipitation events while water is infiltrating into the underground workings. A dewatering system would be in place removing pit water from the underground workings. The overall impacts to access to future mineral reserves and resources would be similar to the No Pit Pond Alternative, and 111,000 cubic yards (167,000 tons) less material would have to be removed, adding little to the waste-to-ore strip ratio.

4.4.5.6 Land Use After Mining

4.4.5.6.1 Suitability of Land Use After Mining

Suitability of land use after mining would be the same as the No Pit Pond Alternative.

4.4.5.7 Aesthetics

4.4.5.7.1 Visual Contrast with Adjacent Lands

Impacts to visual resources would be the same as the No Pit Pond Alternative.

4.4.5.8 Potential Future Burden

4.4.5.8.1 Potential Future Burden on Society

The agencies have assumed that, under the Underground Sump Alternative, the dewatering system would consist of an underground sump, a powerline, and a series of pumps and pipelines to the water treatment plant. The Underground Sump Alternative would have no water leaving the pit bottom to the regional groundwater system even though the pit water table would be lowered 25 to 75 feet compared to the No Pit Pond Alternative.

The consequence of failure of a dewatering system in the underground workings in this alternative would be that the underground workings below the pit would flood and the pit would begin to fill with water after a period of time. The consequence of failure would be similar to the Pit Pond Alternative, which was dismissed in Section 2.5.4, and the No Pit Pond Alternative. Under the Pit Pond Alternative, the water table would rise to the 4,635-foot elevation and stabilize. Under the Underground Sump Alternative, the agencies have assumed that up to 200,000 cubic yards (300,000 tons) of rock would ravel and slough off the pit highwall over time. Even with the 200,000 cubic yards (300,000 tons) of rock in the pit bottom, the water level would stabilize below the 5,050-foot elevation. No water would leave the pit. If the dewatering system failed and a pit pond formed, water could be treated in the pit, pumped to the treatment plant from the pit pond, or the No Pit Pond Alternative could be implemented as a contingency. The agencies believe this alternative offers the most flexibility for future changes in water treatment methods.

4.4.5.8.2 Potential for Future Liabilities for GSM

Under the Underground Sump Alternative, the potential for water quality degradation outside of the pit would be limited. The water level, with pit highwall rock that has sloughed to the pit bottom over time, would not reach the 5,050-foot elevation. No untreated water would leave the pit.

In addition, if the dewatering system failed for any reason, it could be re-established in the underground workings more easily than under the partial pit backfill alternatives. Continued safe access to the dewatering system for operation and maintenance under the Underground Sump Alternative would be less difficult than the No Pit Pond Alternative, as described in Section 4.4.5.1.2.

Raveling and sloughing of the highwall would require construction of a new portal at a higher elevation to maintain access to the underground sump and a secondary escape way over time. Removing water from the underground sump would be easier than pumping out of backfill. GSM contends that this alternative would have the least liability in the future (GSM, personal communication, 2003).

4.5 PROJECT ECONOMICS

4.5.1 Reclamation Costs

The estimated capital and operating costs for GSM to complete the pit reclamation by alternative are presented in Table 4-10. The agency costs would be higher.

Cost assumptions are based on $1.30 per cubic yard for earthwork, 22 cents per cubic yard for cast blasting, and 27 cents per yard for dozing the blasted material. Revegetation is based on a cost of $385 per acre, and the 53 acres of assumed pit and associated pit reclamation common to all alternatives are included. The backfill costs were produced for alternative comparison purposes. The partial pit backfill alternatives do have costs for repairing future settling. This cost is hard to predict but 15 percent has been added to the total cost of these alternative closure plans. These costs were estimated for presenting a relative comparison of alternatives.

Table 4 - 10 Reclamation Costs[1] by Alternative

COST CATEGORY	ALTERNATIVE			
	No Pit Pond	Partial Pit Backfill With In-Pit Collection	Partial Pit Backfill With Downgradient Collection	Under-ground Sump
Haul and Place Backfill in the Sump	$288,000	$288,000	$0	$0
Haul and Place Backfill in the Pit to Free Drain	$0	$43,160,000	$43,290,000	$0
Cast Blast the Highwall	$0	$2,618,000	$2,618,000	$0
Dozer Push the Highwall	$0	$643,000	$643,000	$0
Haul and Place Soil Cover on Revegetated Acres	$755,000	$3,469,000	$3,469,000	$378,000
Construct Storm Water Diversion Structures	$0	$335,000	$335,000	$0
Construct/Reclaim Additional Roads/Miscellaneous Disturbance	$0	$83,000	$83,000	$0
Revegetation	$20,000	$112,000	$112,000	$20,000
Dewatering System Installation	$28,000	$310,000	$470,000	$780,000
QA/QC, Supervision, Misc., Taxes, Insurance	$77,000	$4,337,000	$4,337,000	$82,000
TOTAL COST	$1,168,000	$55,355,000	$55,357,000	$1,260,000

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[1] Costs based on GSM experience and SEIS contractor experience at Zortman/Landusky mines. Agency costs would be higher.

4.6 REGULATORY RESTRICTIONS ANALYSIS

In 1995, the Montana Legislature amended MEPA to require Montana state agencies to evaluate in their environmental documents any regulatory restrictions proposed to be imposed on the use of private property (Section 75-1-201(1)(b)(iv)(D), MCA). Alternatives and mitigation measures designed to make the project meet minimum environmental standards with implementation methods specifically required by federal or state laws and regulations are excluded from evaluation under the Implementing Guidelines for Section 75-1-201(1)(b)(iv)(D), MCA. Alternatives and mitigation measures that are court mandated also are excluded; these measures are a result of court interpretation of the minimum environmental standards of existing federal and state statutes.

A regulatory restrictions analysis was performed in the 1997 Draft EIS, Chapter IV, Section IV.N. Included was consideration of the No Pit Pond Alternative and Partial Backfill Alternative, which are similar to the alternatives evaluated in this SEIS. The costs for pit reclamation have been updated and are shown in Table 4-10.

4.6.1 No Pit Pond Alternative (No Action)

The total cost of implementation of the No Pit Pond Alternative is approximately $1,168,000. This is $54,187,000 less than the cost of the Proposed Action, the Partial Pit Backfill With In-Pit Collection Alternative. All of the mitigations in the No Pit Pond Alternative listed in Section 4.8 would be required to comply with applicable laws and regulations.

4.6.2 Partial Pit Backfill With In-Pit Collection Alternative (Proposed Action)

The total cost of implementation of the Partial Pit Backfill With In-Pit Collection Alternative is approximately $55,355,000. All of the mitigations in the Partial Pit Backfill With In-Pit Collection Alternative listed in Section 4.8 would be required to comply with applicable laws and regulations.

4.6.3 Partial Pit Backfill With Downgradient Collection Alternative

This alternative is a variation on the Partial Pit Backfill With In-Pit Collection Alternative. The total cost of implementation of the Partial Pit Backfill With Downgradient Collection Alternative is approximately $55,357,000. This is virtually the same cost as the Proposed Action, the Partial Pit Backfill With In-Pit Collection Alternative. All of the mitigations in the Partial Pit Backfill With Downgradient Collection Alternative listed in Section 4.8 would be required to comply with applicable laws and regulations.

4.6.4 Underground Sump Alternative

The total cost of implementation of the Underground Sump Alternative is approximately $1,260,000. This is $54,095,000 less than the cost of the Proposed Action, the Partial Pit Backfill With In-Pit Collection Alternative. All of the mitigations in the Underground Sump Alternative listed in Section 4.8 would be required to comply with applicable laws and regulations.

4.7 CUMULATIVE IMPACTS

Cumulative impacts are defined as the impacts that result from the incremental effect of an action, decision, or project when analyzed with respect to other past, present, and reasonably foreseeable future actions. The cumulative impacts of GSM's expansion were analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O. The pit reclamation alternatives evaluated in this SEIS would not add to the cumulative impacts evaluated in 1997.

4.7.1 Past, Present, and Reasonably Foreseeable Future Actions

The agencies have updated the following sections with new information since 1997.

4.7.1.1 Montana Tunnels Mine

Montana Tunnels Mining, Inc. (Montana Tunnels) operates a zinc, lead, silver, and gold mine located 45 miles north of GSM, in central Jefferson County, near Jefferson City. Montana Tunnels has revised its mine plan since 1997 and is still operating. A major expansion is anticipated if permitting is approved. The agencies received the application in July 2004 and are preparing an EIS. The new plan would allow active mining to continue through 2011. Mining could continue past this point, either by continuing the open pit operation or by developing an underground mine. If mining continues until at least 2011, potential impacts from the project would be minimal during closure, as GSM would be completing closure during the same time period and the initial layoffs from the mine closure would have already occurred. If closure of the mines were to be initiated concurrently, unemployment in the region could be compounded. Cumulative impacts to tax revenue losses for the county also could occur if the closures coincided. Details of potential concurrent closure of the two mines were evaluated in a Montana Tunnels environmental assessment (DEQ and BLM, 2002).

4.7.1.2 Ash Grove Cement

Ash Grove Cement Co. (Ash Grove) continues to operate quarries to supply limestone, silica, and shale for its cement plant in Montana City. No major changes have occurred since 1998. DEQ is currently reviewing a proposed permit consolidation plan to combine Ash Grove's six individual permits into one permit for ease of administration by DEQ and Ash Grove.

4.7.1.3 Montana Resources Continental Pit

Montana Resources in Butte, which operates a copper and molybdenum mine, reopened in November 2003 after a 3-year shut down due to low metal prices and high energy prices. Potential cumulative impacts to regional mining employment are not expected, as Montana Resources intends to continue mining. No cumulative impacts to local government finance are anticipated due to the mine's location in a different county. No new cumulative impacts to other resources would be anticipated due to its distance from GSM.

4.7.1.4 Graymont Limestone Mine and Processing Plant

Graymont Western US, Inc. (formerly Continental Lime, Inc.) continues to operate a limestone mine and kiln producing hydrated lime near Townsend. Graymont is the supplier of lime for pH control in the mill at GSM. Graymont's quarry site is located on lands included in the Montana Army National Guard's (MTARNG) Limestone Hills Training Area. MTARNG has applied for a withdrawal covering the training area to ensure that training activities can continue. MTARNG and BLM are coordinating on preparation of a Legislative Environmental Impact Statement. Graymont plans to expand quarry activities farther to the south in the training range. The overall scope of mining activities would not change, and no new cumulative impacts would be anticipated beyond the additional disturbance.

4.7.1.5 Beal Mountain Mine

Pegasus Gold Corporation went bankrupt in 1998. DEQ and the U.S. Forest Service have been reclaiming the Beal Mountain Mine near Gregson since then. The Forest Service is conducting response activities at the site under the Comprehensive Environmental Response, Compensation and Liability Act with input from a technical working group, including DEQ.

4.7.1.6 Exploration Activity at GSM and Other Locations

GSM does not have an ongoing exploration program. An underground mine was developed and completed in January 2004. The cumulative impacts of potential future mining activities cannot be estimated, although GSM contends there is a large mineral resource remaining after mining Stage 5B. Cumulative impacts of exploration activities are not expected to occur, as there is no planned expansion of mining activities outside of current and permitted disturbances. All disturbance related to past exploration activities has been reclaimed. No other mining companies in the area have proposed exploration activities.

4.7.2 Jefferson Local Development Corporation Use of GSM Facilities After Mining

The agencies have reviewed a proposal from GSM to change the land use on a portion of its operating permit area to an industrial park. Part of the facilities and land would be donated to Jefferson County. This change in land use and donation to the county would lessen impacts at mine closure. The agencies approved the change in October 2004.

4.7.3 Past, Present, and Reasonably Foreseeable Future Impacts

The agencies have updated the following sections with new information since 1997.

4.7.3.1 Geology, Minerals, and Paleontology

The cumulative impacts on geology, minerals, and paleontology analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.a would not change as a result of implementing any of the alternatives in this SEIS, even though 56 to 58 acres would be disturbed under the partial pit backfill alternatives, and the pit would be deepened by 125 feet.

4.7.3.2 Water Resources

The cumulative impacts on water resources analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.b would not change as a result of implementing the No Pit Pond, Partial Pit Backfill With In-Pit Collection, or Underground Sump alternatives. The Partial Pit Backfill With Downgradient Collection Alternative would add contaminated water to the groundwater system outside of the pit area, which could also affect surface water quality, as described in Section 4.3.4.2.2.2. Dewatering with downgradient collection wells would lower the regional groundwater level, further affecting groundwater and surface water around the pit area. This is an unavoidable impact of using a groundwater collection system.

4.7.3.3 Soils and Reclamation

The cumulative impacts on soils and reclamation analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.c would not change as a result of implementing the No Pit Pond and Underground Sump alternatives. For the partial pit backfill alternatives, cast blasting to reduce the highwall and construction of additional haul roads to transport backfill material and soil would cause additional disturbance. Soil would be stripped from 56 to 58 acres as a result of cast blasting and haul road construction. Soil salvage would be as deep as possible. Any unsalvageable soil would be lost.

Some soil would be wasted on reclaimed areas where highwall rock would ravel and slough or in areas where backfill settled.

4.7.3.4 Vegetation and Wetlands

The cumulative impacts on vegetation and wetlands analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.d would not change as a result of implementing the No Pit Pond and Underground Sump alternatives. For the partial pit backfill alternatives, cast blasting to reduce the highwall, construct additional haul roads to transport backfill material and soil, and construct new downgradient wells would disturb about 56 to 58 acres. Native vegetation would be lost. Predominantly non-native vegetation communities would be established after the disturbance is revegetated. In addition, native vegetation would be destroyed on soil borrow areas. The borrow areas would be reclaimed with predominantly non-native vegetation. No new wetlands would be disturbed under any of the alternatives.

4.7.3.5 Wildlife and Fisheries Resources

The cumulative impacts on wildlife and fisheries resources analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.e would not change as a result of implementing any of the alternatives in this SEIS. Wildlife habitat impacts are evaluated under Land Use After Mining sections in each alternative.

4.7.3.6 Threatened, Endangered, and Candidate Species

The cumulative impacts on threatened, endangered, and candidate species analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.f would not change as a result of implementing any of the alternatives in this SEIS, even though 56 to 58 new acres would be disturbed in the partial pt backfill alternatives.

4.7.3.7 Air Quality

The cumulative impacts on air quality analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.g would not change as a result of implementing any of the alternatives in this SEIS.

4.7.3.8 Land Uses and Plans

The cumulative impacts on land uses and plans analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.h would not change as a result of implementing any of the alternatives in this SEIS.

4.7.3.9 Aesthetic Resources

4.7.3.9.1 Visual Resources

The cumulative impacts on visual resources analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.i would not change as a result of implementing any of the alternatives in this SEIS. A mitigation has been added that would produce more reclamation of the upper pit highwalls to reduce visual contrast in the No Pit Pond and Underground Sump alternatives. Another mitigation has been added to extend the East Waste Rock Dump Complex across the pit mouth to obscure part of the pit highwall.

4.7.3.9.2 Noise

The cumulative impacts on noise analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.i would not change as a result of implementing any of the alternatives in this SEIS.

4.7.3.10 Socioeconomic Resources

The cumulative impacts on socioeconomic resources analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.j would not change as a result of implementing any of the alternatives in this SEIS unless GSM closed prematurely, then the impacts of closure would occur sooner.

4.7.3.11 Hazardous Materials and Wastes

The cumulative impacts associated with hazardous materials use and storage at the site, analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.k, would not change as a result of implementing any of the alternatives in this SEIS.

4.7.3.12 Cultural Resources

The cumulative impacts on cultural resources analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.l could change as a result of implementing any of the partial pit backfill alternatives in this SEIS. A cabin located near the highwall could be damaged or destroyed when the highwall is cast blasted.

4.7.3.13 Native American Concerns

The cumulative impacts on Native American concerns analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.m would not change as a result of implementing any of the alternatives in this SEIS.

4.8 AGENCY MITIGATION MEASURES

Mitigation measures for the mining operations at GSM were identified in the 1997 Draft EIS, Chapter IV, Section IV.P. Only mitigation and monitoring that could be implemented to mitigate potential impacts from the pit reclamation alternatives being evaluated in this SEIS are discussed in this section.

4.8.1 Technical Issues

4.8.1.1 Pit Highwall

Issue: Pit highwall stability under alternatives that do not require partial pit backfilling.

Measure 1: A plan for monitoring and mitigating raveling and sloughing of the pit highwall would be developed and implemented after closure. Inclinometers and survey prisms currently used to ensure safe mining operations would continue to be used after closure during activities in the pit to monitor ground movement in potentially susceptible areas. A plan concerning entry into the pit after storm events, spring thaws, or after long periods of absence would also be developed.

Horizontal drains and highwall dewatering wells would be maintained and new ones installed where necessary to relieve hydrostatic pressure in the highwall.

Effectiveness: These measures have been proven to be effective during the past 20 years of mining at GSM. These plans would help ensure workers' safety and provide for a mechanism to help maintain pit access.

Application: This measure would apply to the No Pit Pond Alternative and the Underground Sump Alternative.

4.8.1.2 Backfill

Issue: Backfill maintenance.

Measure 2: Backfilled areas would be monitored for settling. If ponding occurred, more soil would be placed to restore the gradient. Gradients would be monitored for settlement along storm water diversions that could result in erosion on the face of the revegetated slopes. Storm water diversion gradients would be reestablished as needed, and any erosion damage would be repaired.

Where localized seeps develop through the soil cover, the seep would be located and dewatered, contaminated soil would be replaced with clean soil, and the area would be revegetated.

GSM would backfill the underground workings remaining after Stage 5B to minimize settlement in the partial pit backfill alternatives. The lowest stope in the underground workings would be maintained as a contingency dewatering sump in the No Pit Pond Alternative.

Effectiveness: This measure would ensure that effects of settlement are minimized and repaired and would ensure dewatering if wells in the backfill failed for any reason.

Application: This measure would apply to all alternatives except the Underground Sump Alternative.

4.8.1.3 Groundwater Effluent Management System

Issue: Identification of secondary flow paths from the pit.

Measure 3: This is a modification of Measure W-10 from the 1997 Draft EIS, Chapter IV, Section IV.P, which was approved as Stipulation 010-13 in the 1998 ROD.

A hydrogeologic investigation would be conducted down gradient of the pit to identify geologic structures that could act as secondary groundwater flow paths east, west, and south of the pit for purposes of monitoring and future groundwater capture of pit seepage. The study would be comprised of geologic mapping, test well drilling, and aquifer testing. The results of the study would be used to determine optimum groundwater monitoring locations and to design a groundwater capture system to minimize impacts to beneficial water uses from pit seepage.

Groundwater capture wells would be installed on secondary pathways when monitoring indicates a need. Based on previous studies of groundwater capture in bedrock and experience in drilling wells at GSM, it is estimated that at least two capture wells would initially be required for each structure with evidence of ARD migration. Testing and monitoring would be required to determine whether two wells achieved sufficient capture efficiency. Existing and potential monitoring and capture well locations are listed in Table 4-8 and shown on Figure 2-7 in the SEIS.

Effectiveness: A hydrogeological investigation to identify secondary flow paths down gradient of the pit would increase the efficiency of the proposed groundwater capture system. Wells installed as a result of this study would reduce the problem of complying with applicable groundwater quality standards and would protect springs and beneficial uses of the Jefferson River alluvial aquifer.

Application: This measure would apply to the Partial Pit Backfill With Downgradient Collection Alternative.

Issue: Dewatering system damage from highwall raveling and sloughing.

Measure 4: As a contingency in case the dewatering system were damaged, destroyed, or became inaccessible, the agencies would require GSM to submit a plan for development, maintenance, and monitoring of a portal at a suitable elevation to allow access to the underground workings, so that dewatering would still be possible using an underground sump. If the 4,550-foot-elevation portal became inaccessible, GSM would have to establish a third portal.

Effectiveness: This contingency would allow dewatering to continue to keep the water table from rebounding if the dewatering system is damaged or destroyed and cannot be reestablished.

Application: This measure would apply to the No Pit Pond Alternative and the Underground Sump Alternative.

Issue: Access to the dewatering system in the pit.

Measure 5: Highwall safety benches, especially the 5,700-foot safety bench, and safety berms around the pit floor working surface would be maintained to catch rock that ravels and sloughs from the highwall after closure. The pit haul road would be maintained for access. Rock raveling and sloughing from the highwall and escaping the safety benches and berms would be moved. The working surface on the pit floor would be graded to move the rocks and resoiled if necessary.

Effectiveness: Maintenance of safety benches, berms, and the haul road would ensure that the dewatering system in the pit would be accessible.

Application: This measure would apply to the No Pit Pond Alternative and the Underground Sump Alternative.

Issue: Dewatering system monitoring.

Measure 6: GSM would install and maintain a remote monitoring system for wells, pumps, pipelines, powerlines, etc. to minimize the need for workers to be in the pit area or underground workings and to ensure water is captured efficiently.

A dewatering monitoring system performance program would be implemented to monitor progress of the dewatering, evaluate the effectiveness of the system, and document the volume and quality of water pumped from the pit or underground sump.

Effectiveness: A remote monitoring system would ensure the proper functioning of the dewatering system while protecting workers by not requiring them to visit dewatering system components frequently. The system performance program would track the efficiency of the dewatering system and identify potential for improvement.

Application: This measure would apply to all alternatives.

Issue: Dewatering system failures.

Measure 7: Dewatering wells, pumps, access roads, powerlines, and pipelines would be repaired or replaced as needed to maintain dewatering system operations.

Effectiveness: Maintaining dewatering system components in good order will protect groundwater quality.

Application: This measure would apply to all alternatives.

Issue: Failure of the dewatering system in the Partial Pit Backfill With Downgradient Collection Alternative.

Measure 8: If the Partial Pit Backfill With Downgradient Collection Alternative were selected and the downgradient capture system does not prevent impacts at the mixing zone boundary, dewatering wells would be installed in the backfilled pit as in the Partial Pit Backfill With In-Pit Collection Alternative.

Effectiveness: This measure would minimize the potential for pit discharge.

Application: This measure would apply to the Partial Pit Backfill With Downgradient Collection Alternative.

Issue: Access to the underground workings.

Measure 9: Access to the underground would be needed for a primary or contingency pit dewatering system. The agencies have assumed that the 4,550-foot elevation portal to the underground workings would be buried by rocks raveling off the highwalls and a mass failure over time. The agencies would require GSM to submit a plan for development, monitoring, and maintenance of a new portal at a suitable elevation for access long term. The agencies would bond for maintenance of access and regular repair and replacement of dewatering system components.

This would require additional powerlines, pipelines, and maintenance of access roads in the underground workings to ensure integrity of the dewatering system and provide secondary access for workers. Monitoring of the underground workings would be required to ensure the integrity of the walls and ceiling.

A monitoring and maintenance plan would be needed to ensure continued access to repair the dewatering system and to ensure worker safety. The monitoring and maintenance plan would be applied to both the 4,550 and contingency portal locations. If the 4,550-foot-elevation portal became inaccessible, GSM would have to establish a third portal.

Effectiveness: Secondary portals would provide access to the underground workings, a backup dewatering system, and an escape way for workers.

Application: This measure would apply to the No Pit Pond Alternative and the Underground Sump Alternative.

4.8.1.4 Storm Water Runon/Runoff Management

Issue: Storm water diversion maintenance.

Measure 10: Storm water diversions would be monitored regularly for integrity and gradient. Sediment accumulations and/or rockfalls from upgradient slopes would be removed. If the gradient changed from settling resulting in low spots, the diversion would be returned to the proper gradient, resoiled, and seeded as necessary

Effectiveness: The maintenance requirements for the storm water diversions would ensure the ability of the diversions to route water away from the pit area over time.

Application: This measure would apply to all alternatives.

4.8.1.5 Soil Cover

Issue: Monitoring and testing of soils affected by steam venting at the waste rock dump test plots and tracking number and size of vents on all reclaimed surfaces over acid-producing materials.

Measure 11: This is Measure S-1 from the 1997 Draft EIS, Chapter IV, Section IV.P, which was approved as Stipulation 010-14 in the 1998 ROD.

A program would be implemented for the continued monitoring of existing waste rock test plots and surfaces that are reclaimed over acid-producing materials to further assess the impacts, if any, that steam venting may have on reapplied soil or establishing vegetation. The program would consist of GSM or agency reclamation specialists annually monitoring the number, location, and size of steam vents and extent of modified plant communities surrounding vent locations. If detrimental effects to establishing vegetation communities are observed on more than 0.1 percent of the total reclaimed area covering acid-producing materials, GSM would be required to: 1) rock armor vent locations to prevent erosion and spreading of vent locations, 2) sample and test soils at vent locations, and 3) prepare a detailed plan to further reduce the expansion of steam vents and minimize potential impacts to reclamation success. Soil parameters to be tested would correspond to those which appear to have given rise to the change in vegetation communities. At a minimum, soil pH and ABA should be evaluated for each sample collected. The general cost for such a program should be included in a post-mine maintenance bond.

Effectiveness: This would be an effective means of assessing and mitigating the changes occurring, if any, through time to reapplied soil materials and vegetation communities as a result of steam venting. The results of testing would be directly applicable to assessing whether steam venting had a negative effect on establishing vegetation communities.

Application: This measure would apply to all alternatives.

Issue: Pit reclamation maintenance.

Measure 12: Any acreage revegetated in the pit would be monitored for rock raveling and sloughing, backfill settling, erosion, and noxious weeds. Rock that has raveled or sloughed would be removed or covered with new soil. Areas that have settled would be filled to grade with additional soil. Eroded areas would be repaired, resoiled, and reseeded. Noxious weeds would be controlled.

Effectiveness: This measure would ensure that revegetated areas are maintained.

Application: This measure would apply to all alternatives.

Issue: Reclamation soil rock content for 2H:1V slopes.

Measure 13: GSM would perform further testing to verify that soils from the proposed borrow site north of Tailings Impoundment No. 2 has the rock size and characteristics that are adequate for use on 2H:1V slopes. An amendment to add rock fragments would be required if necessary.

Effectiveness: This measure would ensure that soil placed on 2H:1V slopes in the pit would be protected from erosion.

Application: This measure would apply to all alternatives.

4.8.1.6 Water Treatment

Issue: Total of combined inflows to permanent water treatment plant exceeds the capacity of the plant.

Measure 14: This is Measure W-6 from the 1997 Draft EIS, Chapter IV, Section IV.P, which was approved as Stipulation 010-9 in the 1998 ROD.

The capacity of the permanent water treatment plant would be reevaluated and incorporated into the final design within 2 years prior to projected mine closure. At that time, the actual rate and quality of pit inflow during peak flow and low flow periods, and the total rate and quality of groundwater captured in the tailing area will be better known.

Based on the degree of uncertainty of the rate of inflow from future sources, a contingency measure of up to 25 percent additional flow would be incorporated into the treatment plant capacity, and a contingency to provide storage for up to 6 months of anticipated water inflow would be included. This would provide for time to modify the plant if needed for unanticipated future inflows.

Alternatively, a new, additional water treatment facility would be constructed to address treatment of a specific source or sources. This supplemental water treatment facility would be built at the time such sources are identified. This alternative measure may be considered for treatment of waste rock dump ARD because the time frame before ARD impacts are anticipated to occur is longer than a reasonable design life of the permanent water treatment plant that will be built at the end of mining.

Effectiveness: Sufficient additional water treatment capacity, whether added to the permanent water treatment plant design or as an additional separate facility, would provide for treatment of unanticipated inflows.

Application: This measure would apply to all alternatives.

4.8.2 Environmental Issues

4.8.2.1 Impacts to Groundwater Quality and Quantity

Issue: Compliance with groundwater standards down gradient of the pit.

Measure 15: The Rattlesnake Gulch dewatering wells and Tailings Impoundment No. 1 south pump back system wells would be operated together to try to achieve at least a 95 percent capture efficiency of groundwater in the Tdf/colluvial aquifer down gradient of the pit to achieve compliance with groundwater standards for nickel and the other metals. If monitoring shows that an overall 95 percent capture is not being achieved, more wells would be installed.

Effectiveness: This measure would minimize impacts to the Jefferson River alluvial aquifer, but it cannot be guaranteed that sufficient wells can be installed to prevent water quality violations.

Application: This measure would apply to the Partial Pit Backfill With Downgradient Collection Alternative.

Issue: Impacts to beneficial uses in the Jefferson River alluvial aquifer.

Measure 16: Water would be discharged from the permanent water treatment plant back to the aquifer as recharge, or to discharge as surface water in order to minimize impacts to downgradient beneficial uses.

Effectiveness: This measure would minimize impacts to beneficial uses of water down gradient of the groundwater capture system in the Jefferson River alluvial aquifer or the Jefferson River and Slough.

Application: This measure would apply to all alternatives.

Issue: Modification of the groundwater mixing zone to include pit discharge.

Measure 17: Pit discharge was not included in the groundwater mixing zone statement of basis in the 1998 Final EIS, Appendix 1. The flow paths from the pit are within the permitted GSM mixing zone. GSM would have to submit an application to modify the approved mixing zone. DEQ would modify the 1998 Statement of Basis for the mixing zone.

Effectiveness: The mixing zone analysis and the statement of basis modification would ensure compliance with groundwater quality standards at the mixing zone boundary.

Application: This measure would apply to the Partial Pit Backfill With Downgradient Collection Alternative.

4.8.2.2 Impacts to Surface Water Quality and Quantity

Issue: Identification and replacement of altered discharge or reduced water quality at springs and seeps.

Measure 18: This is a modification of Measure W-1 from the 1997 Draft EIS, Chapter IV, Section IV.P, which was approved as Stipulation 010-4 in the 1998 ROD.

A monitoring program would be established to quantify discharge and water quality at springs in the project area and to identify any reductions or increases in flow or changes in water quality. Data would be collected often enough to detect spring response to seasonal variations and pit dewatering.

Mitigation of reduced discharge at springs would be accomplished by further development of the affected spring or by diverting water from the permanent water treatment plant to provide water for wildlife and livestock use. Further development of the spring would involve improving collection and storage of spring discharge and/or expanding the interception area of the spring at the water table.

Mitigation would be required if spring discharge increased by more than 15 percent of the baseline spring flow, or if water quality declined. If flow increased or water quality decreased, the spring water would be collected and routed to the water treatment plant for treatment and disposal.

Mitigation of reduced water quality would be accomplished by establishing additional water sources for wildlife and livestock use. Treated water from the permanent water treatment plant would be discharged as surface water for wildlife and livestock use.

Any change in the quantity and/or quality of springs and seeps, and their associated source of contaminants, would be subject to an MPDES permitting review by DEQ. For bonding purposes, under the Partial Pit Backfill With Downgradient Collection Alternative, the agencies have assumed that one existing spring, Stepan Spring, would have a 15 percent increase in flow that would have to be collected and treated, and that one new spring discharging 1.5 gpm would develop and would be collected and treated under an MPDES permit.

Effectiveness: This measure would document variations in spring discharge and spring water quality and provide data to determine if changes in spring flows or water quality occur during and after mining. This measure also would provide continued surface water sources at the mine site, reducing impacts to wildlife and livestock.

Application: This measure would apply to all alternatives.

Issue: ARD release from waste rock dump complexes or the pit area that is either premature because of transport along preferential, discrete flow paths and/or of greater flow rate than modeled performance because of higher than expected infiltration.

Measure 19: This is Measure W-4 from the 1997 Draft EIS, Chapter IV, Section IV.P, which was approved as Stipulation 010-7 in the 1998 ROD.

If the data from existing monitoring wells and/or spring flows indicate that changes in water quality are occurring which are likely to exceed applicable regulatory requirements, the following mitigation measures would be employed:

a) If water quality impacts are detected in monitoring wells at the mixing zone boundary down gradient from the East Waste Rock Dump Complex, localized capture of groundwater may be needed to contain ARD transport along preferential, discrete flow paths that were not anticipated by the ARD fate and transport model (see the 1997 Draft EIS, Appendix J). A groundwater capture system similar to the system described in Appendix A for the West Waste Rock Dump Complex would be installed. Capture of discrete plumes from the East Waste Rock Dump Complex would not require a well system as extensive as assumed for the West Waste Rock Dump Complex. The contingency design in the 1997 Draft EIS, Appendix A that provides for treatment of approximately 20 percent of the predicted flux on the east side is considered adequate for this mitigation measure.

b) ARD-impacted seeps may emerge at the toes of the dumps where preferential drainage paths occur within the dumps that lead to discrete "perched" saturated zones at their base. Shallow groundwater capture systems such as toe drains around the peripheries of the waste rock dumps would be installed to supplement the primary, deep capture well system; or

c) *In situ* treatment systems would be installed in the shallow ("perched") aquifer zones, including the alluvial materials over bedrock on the west side, and/or the colluvial/alluvial materials in Rattlesnake Gulch or at other locations down gradient of the East Waste Rock Dump Complex. One example of this type of emerging technology is a funnel and gate approach which incorporates groundwater barriers that “funnel” the identified contaminant plume(s) through constrained location(s) within the shallow aquifer. *In situ* reaction walls, such as limestone-filled trenches, are installed at these “gate” locations. The reaction walls provide essentially “semipervious” barriers which allow water to pass but “filter” the dissolved metals or other contaminants.

Effectiveness: The supplemental groundwater capture systems described would allow interception of contaminated groundwater that bypasses the primary capture well system. ARD-impacted groundwater could bypass the capture wells along shallow perched flow paths around the peripheries of all the dumps, or move through high conductivity preferential flow paths down gradient from the East Waste Rock Dump Complex. The supplemental systems described will provide for capture of these potential ARD sources before the contaminated water migrates down gradient to beneficial uses, or to sensitive receptors, such as the Jefferson River.

Application: These measures would apply to all alternatives.

4.8.3 Socioeconomic Issues

4.8.3.1 Safety

Issue: Worker safety within the pit.

Measure 20: A 70-foot-wide safety bench at the 5,700-foot elevation would be left around three sides of the pit for additional protection. One or more berms would be constructed around the perimeter of the working area on the pit bottom in the No Pit Pond Alternative to trap incidental rocks that may fall from the highwall. The access road leading down to the working surface on the pit bottom from the 4,875-foot elevation would be widened by extending the road to the south over a portion of the 4,800-foot-elevation area and away from the highwall toe.

The agencies would require the development of secondary portals at suitable elevations in the pit as a secondary escape ways.

Effectiveness: These measures would provide additional protection to workers in the pit, but there would continue to be hazards associated with working in the pit.

Application: This measure would apply to the No Pit Pond Alternative and the Underground Sump Alternative.

4.8.3.2 Aesthetics

Issue: Visual contrast with adjacent lands.

Measure 21: About 37 acres in the pit would be treated with the following measures to reduce the visual contrast with adjacent lands, if they can be accomplished safely:

- End dumping and/or cast blasting would occur along the upper portion of the northwest and west highwalls, and these areas would be seeded and possibly planted with trees.
- Dozer work would be completed on the recent slide area on the west highwall, and this area would be seeded and possibly planted with trees.
- Soil sampling on the old slide area on the northwest highwall would be completed, and this area would be seeded and possibly planted with trees.
- Soil would be placed on the highwall bench above the 5,700-foot safety bench, and the area would be seeded and possibly planted with trees.
- Trees would be planted where possible on the 5,700- and 5,400-foot safety benches.

Effectiveness: Sharp lines and forms in the pit would be softened. Pit highwall rock weathering and vegetation over the long term would blend with the color and texture of the natural landscape. Portions of the highwalls and benches would remain visible. Overall visual contrasts would be reduced to a level where they are noticeable but not dominant in the landscape, following successful reclamation and revegetation. Landscape modifications would be consistent with the suggested VRM Class III rating for the area.

Application: This measure would apply to the No Pit Pond Alternative and the Underground Sump Alternative.

Measure 22: The East Waste Rock Dump Complex would be extended back across the mouth of the pit to tie into the natural slope and partially screen the view of the northeast corner of the pit highwall.

Effectiveness: Views of the northwest portion of the pit highwall would be partially obscured.

Application: This measure would apply to the No Pit Pond Alternative and the Underground Sump Alternative.

4.8.4 Other Issues

Issue: Cultural resource protection.

Measure 23: GSM would prepare and execute a mitigation plan for the cabin located near the highwall, if it is threatened by cast blasting.

Effectiveness: A mitigation plan would ensure that the cabin is protected, or that historical data are properly collected and recorded before it is damaged or destroyed.

Application: This measure would apply to the Partial Pit Backfill With In-Pit Collection Alternative and the Partial Pit Backfill With Downgradient Collection Alternative.

4.9 UNAVOIDABLE ADVERSE IMPACTS

Unavoidable adverse impacts were addressed in the 1997 Draft EIS, Chapter IV, Section IV.Q. That analysis included evaluating unavoidable impacts that could result from expansion of mining activities, as well as reclamation activities. Implementation of the potential mitigation measures identified in the 1997 Draft EIS was to reduce most adverse impacts that were identified. This SEIS updates that analysis.

4.9.1 Technical Issues

The technical issues described and evaluated in this section relate primarily to stability, maintainability, and operating requirements of engineered structures and water management facilities as they relate to pit reclamation. The technical issues were evaluated in conjunction with the environmental and socioeconomic issues. The evaluation of the other issues assumed that the issues in the technical section function as designed and constructed. The success of the technical issues directly affects other issues.

Unavoidable impacts related to the technical issues include impacts associated with the pit highwall, groundwater effluent management system, storm water runon/runoff management, soil cover, water treatment, and flexibility for future improvements.

In alternatives that do not include large amounts of backfilling, it is expected that some portions of the pit highwall would be subject to raveling and limited sloughing, which are unavoidable. This movement could result in impacts to the dewatering system and pose safety concerns for workers in the pit. Limited environmental impacts would occur outside of the pit as a result of raveling and sloughing over time.

In regard to the groundwater effluent management system, the Partial Pit Backfill With In-Pit Collection Alternative would include a large amount of backfill and would encounter additional problems with pumping water from the pit. Due to the amount of backfill required and the characteristics of the backfill material, these problems are unavoidable. If the dewatering system fails, environmental impacts to regional groundwater could occur outside of the pit.

Storm water runon/runoff management activities would be required regardless of the alternative selected. The need for managing storm water diversions over acid producing waste would result in long-term maintenance needs.

The alternatives would result in the need for 3 feet of soil for covering the acid generating waste rock on 52 to 292 acres in the pit (Table 4-6), depending on the alternative. As needed, this soil would be removed from borrow areas on the mine site.

A small volume of soil would be lost to erosion during salvage and reapplication activities and following seeding until vegetation becomes established. The partial pit backfill alternatives are subject to settlement after reclamation, which could result in some limited soil loss and soil additions to reestablish grades. Under the No Pit Pond and Underground Sump alternatives, some soil on reclaimed areas in the pit would be lost adjacent to highwalls by raveling and sloughing rock.

Water treatment would be required regardless of the alternative chosen. GSM is currently bonded for long-term water treatment and this is unavoidable. Water treatment would result in the need to manage discharge water and sludge generated by treatment activities.

Opportunities exist for improvements to existing water management practices and plans in the future that could reduce contamination and provide lower cost treatment alternatives. Partial pit backfill alternatives could reduce the possibility of continued research and development of these opportunities within the pit backfill.

4.9.2 Environmental Issues

Unavoidable impacts related to environmental issues include impacts to groundwater quality and quantity, surface water quality and quantity, and reclamation plan changes.

Under the alternatives that maintain the pit as a hydrologic sink, dewatering the pit has reduced groundwater levels in the pit vicinity during operation. Continued pumping of groundwater for treatment, as part of reclamation, would result in lower groundwater levels for as long as pumping continues. The reduced groundwater levels could impact discharges from local seeps and springs. Intercepted pit water is removed from the local hydrologic system. During operation, this water is used in the processing circuit. Following mine closure and reclamation, most of this water would be returned to the local groundwater system in another drainage down gradient of the water treatment plant after treatment to avoid recontamination of that water in the flow path below the pit.

Under the Partial Pit Backfill With Downgradient Collection Alternative, the regional groundwater system in the pit would return to the level before mining. The water table down gradient of the pit would be drawn down around the capture wells. This is an unavoidable impact of downgradient dewatering using a groundwater capture system.

The Partial Pit Backfill With Downgradient Collection Alternative would result in contaminated groundwater leaving the pit and entering the local groundwater system. This water would impact the groundwater quality to the point of collection. If collection is not 95 percent effective adverse impacts would result at the mixing zone boundary.

No direct adverse impacts to wetlands have been identified. Indirect hydrologic impacts could occur to area springs under all alternatives.

There are 158 to 159 acres of pit area under the No Pit Pond Alternative and Underground Sump Alternative that would be reclaimed as highwall and not revegetated.

Reclamation for all of the alternatives requires diversion of surface water flows around waste rock dump complexes and the pit.

No changes from the unavoidable adverse impacts discussed for the waste rock dump complexes in the 1997 Draft EIS, Chapter IV, Section IV.Q are expected as a result of the reclamation plans evaluated in this SEIS.

4.9.3 Socioeconomic Issues

Unavoidable adverse impacts related to socioeconomic issues include impacts to mining employment, tax revenues, mineral reserves and resources, and land use after mining. Impacts to mining employment and tax revenues would occur if GSM decides to stop mining Stage 5B if a partial pit backfill alternative is selected.

No unavoidable adverse impacts to access to future mineral reserves and resources have been identified for the No Pit Pond Alternative and the Underground Sump Alternative. The Partial Pit Backfill With In-Pit Collection Alternative and the Partial Pit Backfill With Downgradient Collection Alternative would place 47,000,000 cubic yards of waste rock and soil back into the pit. This backfill material would bury the remaining potential mineral resource and would potentially make it uneconomic for future open pit extraction of ore by increasing waste-to-ore strip ratios.

Long-term loss of 158 to 159 acres of native wildlife habitat for species such as mule deer would occur under the No Pit Pond and Underground Sump alternatives. The alternatives that would result in the largest loss of mule deer habitat would also result in a small gain of habitat for other wildlife species, such as raptors and bats.

Unavoidable adverse impacts for land use include areas disturbed by mining activity and the loss of grazing resources in the Bull Mountain Allotment and Hill and Wilkerson Allotment.

4.10 SHORT-TERM USE VERSUS LONG-TERM PRODUCTIVITY

The 1997 Draft EIS, Chapter IV, Section IV.R addressed short-term use versus long-term productivity. This SEIS only addresses changes to productivity that would occur as a result of pit reclamation alternatives. Short term is defined as the life of GSM through closure and reclamation (2011). Long term is defined as the future beyond reclamation. Many of the impacts associated with all alternatives would be short term and would cease following successful reclamation.

Soil and vegetation short-term productivity would be reduced on the 56 to 58 acres of new disturbance under the partial pit backfill alternatives. Assuming revegetation is successful, and soil development and vegetation succession occur, long-term soil productivity would be restored. The permanent loss of 158 to 159 acres of native vegetation and wildlife habitat under the No Pit Pond and Underground Sump alternatives would be partially offset by productivity of the acreage revegetated with predominantly non-native species.

Noxious weeds are increasing in areas around the mine and across Montana. Regardless of control efforts, noxious weeds will increase on the pit disturbed area for all alternatives, affecting long-term productivity of desirable species. Plant community composition would be altered by the noxious weeds and control activities. This is an unavoidable impact of noxious weed presence and control.

4.11 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The 1997 Draft EIS, Chapter IV, Section IV.S addressed irreversible and irretrievable commitments of resources. This SEIS only addresses changes to irreversible and irretrievable commitments of resources that would occur as a result of pit reclamation alternatives. Irreversible is a term that describes the loss of future options. It applies primarily to the effects of use of nonrenewable resources, such as minerals or cultural resources, or to those factors, such as soil productivity, that are renewable only over long periods of time. Irretrievable is a term that applies to the loss of production, harvest, or use of natural resources. For example, livestock forage production from an area is lost irretrievably while an area is serving as a mining area. The production lost is irretrievable, but the action is not irreversible. If the use changes and the mine is reclaimed, it is possible to resume forage production. Irreversible and irretrievable impacts under all alternatives are similar to those analyzed in the 1997 Draft EIS.

One irreversible loss addressed in this SEIS involves the ability to adapt to future technologies. Prevention and treatment technologies for ARD are continually evolving and becoming more effective. For alternatives involving partial pit backfilling, the ability to adapt to future changes in technology may be limited.

GSM contends the partial pit backfill alternatives would limit the potential for future mining and recovery of remaining mineral resources and reserves.

4.12 ENERGY REQUIREMENTS AND CONSERVATION POTENTIAL

Energy for Stage 5B and the reclamation alternatives would be essentially the same as listed in the 1997 Draft EIS, Chapter IV, Section IV.T.

The Partial Pit Backfill With In-Pit Collection Alternative and the Partial Pit Backfill With Downgradient Collection Alternative would have increased diesel fuel consumption for grading slopes to 2H:1V and backfilling waste rock from the East Waste Rock Dump Complex into the pit. The life-of-project diesel fuel consumption increases from the 13,000,000 gallons for Stage 5B and the No Pit Pond Alternative to 22,000,000 gallons for the two partial pit backfill alternatives. Pumping from the underground workings under the Underground Sump Alternative would add a very minimal amount of electrical demand.

Chapter 5

Consultation and Coordination

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Chapter 5

Consultation and Coordination

5.1 AGENCIES, ORGANIZATIONS, AND INDIVIDUALS CONSULTED

In the course of preparation of the Draft SEIS for the Golden Sunlight Mine (GSM), the DEQ and BLM communicated with and received input from federal, state, and local agencies, elected representatives, environmental and citizens groups, companies, and individuals. This list of agencies, organizations, and individuals includes those individuals present at the Public Scoping and the Whitehall Community Transition Advisory Committee meetings held in Whitehall, and the MAA meetings.

5.2 PUBLIC PARTICIPATION

5.2.1 Scoping Meeting

A public scoping meeting was held on July 16, 2003 at the Middle School in Whitehall, Montana. A total of 164 people signed in at the meeting, and there were approximately another 30 who declined to sign the register. The meeting commenced with an explanation of the meeting's purpose presented by DEQ. The General Manager of GSM spoke on the history of the mine. This was followed by a presentation by the agencies of the seven alternatives being actively studied in preparation of the SEIS.

Twenty-six attendees at the public scoping meeting made statements, all against partial pit backfill at GSM. Representatives of BLM and DEQ answered questions raised by participants of the meeting.

A total of 76 comments have been received, 71 letters or e-mails, and five comment forms completed during the public meeting. There were a total of 120 signatures on the comments, and 12 comments were on form letters. Of the 76 comments received, 73 expressed strong opinions against partial pit backfill. Seven letters were from local, state, or federal representatives.

5.2.2 Whitehall Community Transition Advisory Committee

On September 9, 2003, another public meeting was held at the Whitehall Middle School, called by the Whitehall Community Transition Advisory Committee, a locally based stakeholder group interested in the future and reclamation of GSM. This meeting again showed the interest of the local and surrounding communities in the process. Both DEQ and BLM representatives attended the meeting.

A total of 117 people attended the meeting. Similar to the Public Scoping Meeting, the persons making statements at this meeting were strongly against the partial pit backfill approach to GSM reclamation.

5.2.3 MAA Process

To assist the agencies in determining the range of alternatives to be evaluated in the SEIS, DEQ and BLM initiated a Multiple Accounts Analysis (MAA) process. The MAA process is described in detail in Robertson GeoConsultants (2003) and summarized in Section 1.7.2

5.3 PERSONS AND ORGANIZATIONS RECEIVING THE SEIS

Agencies, organizations, and individuals who received copies of the Draft SEIS are listed below:

Federal Agencies

U.S. Department of Defense Chief, Planning Division Missouri River Division Corps of Engineers PO Box 103 Downtown Station Omaha, NE 68101 (2)	U.S. Department of Defense Office of Deputy A/S of the USAF Environment, Safety, Occupational Health SAF/HQ Room 4C916, Pentagon Washington, DC 20330-0001
U.S. Department of Defense HQ-USAF/LEEV Environmental Division Bolling AFB, Building 516 Washington, DC 20330-5000 (2)	U.S. Department of Energy Office of Environmental Compliance (EH-23) 1000 Independence Avenue, S.W. Washington, DC 20585 (2)
U.S. Department of the Interior Jim Beaver Bureau of Land Management 5001 Southgate Dr Po Box 36800 Billings, MT 59107	U.S. Department of the Interior Brenda Williams, WO-480 Bureau of Land Management 1620 L Street NW, Room 1075 Washington, DC 20036
U.S. Department of the Interior Joan Gabelman Bureau of Land Management 106 N. Parkmont Butte, MT 59701 (2)	U.S. Department of the Interior Scott Haight Bureau of Land Management PO Box 1160 Lewistown, MT 59457
U.S. Department of the Interior Dave Williams Bureau of Land Management 106 N Parkmont Butte, MT 59701-7222	U.S. Department of the Interior U.S. Fish and Wildlife Service PO Box 30396 Billings, MT 59107
U.S. Department of the Interior Bureau of Reclamation Denver Federal Center (D-150) Building 67 PO Box 2507 Denver, CO 80225 (2)	U.S. Department of the Interior Fish and Wildlife Service Chief, Division of Env. Coordination Washington, DC 20240 (3)

U.S. Department of the Interior National Park Service Division of Environmental Compliance (762) 1849 C Street NW Room 2749 Washington, DC 20240-0001 (4)	U.S. Department of the Interior Offshore Environmental Assessment Division Minerals Management Service Washington, DC 20240 (3)
Office of Federal Activities (A-104) Environmental Protection Agency Room 2119 Mall Attn: Management Information Unit 401 M Street SW Washington, DC 20460 (5)	U.S. Department of the Interior Phillis Davis USDI Director-Office of Environmental Policy & Compliance 1849 C Street, NW (MS2340) Washington, DC 20240-001 (5)
U.S. Department of the Interior USDI Natural Resources Library 1849 C Street NW (MS 2258) Washington, DC 20240 (3)	U.S. Department of the Interior USDI Office of Public Affairs 1849 C Street NW (MS 7031) Washington, DC 20240
U.S. Department of the Interior USFWS 100 North Park Ave. Helena, MT 59601	Environmental Affairs Program U.S. Geological Survey National Center (423) Department of the Interior Reston, VA 22092 (3)
U.S. Environmental Protection Agency Environmental Review Coordinator EPA Region VIII 999 18th Street, Suite 1300 Denver, CO 80202-2413	U.S. Environmental Protection Agency Phil Strobel EPA 999 18th St., Suite 500 Denver, CO 80202-2466 (5)
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Chapter 6
Comments

7.1 INTRODUCTION 6-1

7.2 SCOPING.. 6-1

Chapter 6
Comments

6.1 INTRODUCTION

Chapter 6 of the final SEIS will contain the public comments received on the Supplemental EIS and the agencies' responses to those comments.

6.2 SCOPING

During the scoping period a total of 76 public responses were sent in with 120 signatures. A list of those people supplying comments is shown in Table 6-1. The comments are on file at the DEQ offices in Helena.

Table 6-1 Scoping Comments Received, Golden Sunlight Mine SEIS

Letter Number	Organization Type	Organization	Name	Number Signatures	Response Type	Delivery Type	Immediate Attention	Information Request
1	Environmental	MEIC,NWF	Jim Kuipers	1	Ltr	Mail	Litigation	
2	Fed Govt	EPA	Cynthia Cody	1	Ltr	Mail	Fed Govt	
3	Individual		Paul Richards	1	Ltr	Email		Furnish Info
4	Individual		James A. Liebetrau	1	Ltr	Mail		
5	Business	GCR/COBRE TIRE	Marcus Duhame	1	Form Ltr	Mail		
6	Business	GCR/COBRE TIRE	Cherye Sullivan	1	Form Ltr	Mail		
7	Business	GCR/COBRE TIRE	Cel Schroeder	1	Form Ltr	Mail		
8	Business	GCR/COBRE TIRE	Nancy Smith	1	Form Ltr	Mail		
9	Individual		Joseph M Dillon	1	Ltr	Mail		
10	Business	MT Broom & Brush	Mike Hitchcock	1	Ltr	Mail		
11	Business	Butte's Boots & Shoe Repair	Dan Schroeder	1	Ltr	Mail		
12	Business	GCR/COBRE TIRE	Douglas Duhame	1	Form Ltr	Mail		
13	Business	GCR/COBRE TIRE	John Knutson	1	Form Ltr	Mail		
14	Business	Cardwell Store & RV Park	Kipp Huckaba	1	Ltr	Mail		
15	Individual		John Pullman	2	Ltr	Email		
16	Individual		Charlene Dillon	1	Ltr	Email		
17	Individual		Kerry Weightman	1	Ltr	Email		
18	Individual		Doc Jordan	1	Ltr	Mail		
19	Individual		Debra Streadwick	1	Comment Form	Hand-Del		Furnish Info
20	Enviro / Atty	Natl Wildlife Fed & Reynolds, Motl….	Thomas France & David Wilson	2	Ltr	Mail	Litigation	Meeting Req
21	Business	PPL EnergyPlus	Mark Zora	1	Ltr	Mail		
22	Ranch	LR Huckaba Ranch	Huckaba-Leonard R, Susanne L., Leonard W	3	Ltr	Mail		
23	Individual		Donna Heikkinen	1	Ltr	Mail		
24	Individual		Clifford Hoopes	1	Ltr	Mail		

Letter Number	Organization Type	Organization	Name	Number Signatures	Response Type	Delivery Type	Immediate Attention	Information Request
25	Individual		Ron Tuohimaa	1	Ltr	Mail		
26	Local Govt	Jefferson County Commission	Sherry Cargill, Tomas Lythgoe, Chuck Notbohm	3	Ltr	Mail	Local Govt	
27	Individual		Robert Lombardi	1	Ltr	Mail		
28	Individual		Larry Hoffman	1	Ltr	Email		
29	Union	IBEW Local #768	Larry Langley	1	Ltr	Email		
30	Individual		Philip Mulholland	1	Ltr	Email		
31	Individual		Michael Oelrich	1	Ltr	Email		
32	Business	MT Electric Motors	Dale Olson & Crew	1	Ltr	Email		
33	Individual		Rick Jordan	1	Ltr	Email		
34	Individual		Cassie Heikkinen	1	Comment Form	Mail		
35	Individual		Scott Cook	1	Ltr	Mail		
36	Individual		Cory Vollmer	1	Ltr	Mail		
37	Individual		Don Staley	1	Ltr	Mail		
38	Business	Headwaters RC&D	James Davison	1	Ltr	Mail		
39	Business	Smith and Sons	Smith-John & Olive	2	Form Ltr	Mail		
40	Business	Small Mine Devel	Lou Myers	33	Ltr	Mail		
41	Individual		John Stratton	1	Ltr	Email		
42	Individual		Betty Salvagni	1	Ltr	Email		
43	Individual		Diane Jordan	1	Ltr	Email		
44	Individual		Ken Huguiet	1	Ltr	Email		
45	Business	MSE Technology	Jay McCloskey	1	Ltr	Email		
46	Individual		Park-Brian & Margarita	1	Ltr	Email		
47	Individual		Bill Seybert	1	Ltr	Email		
48	Business	Allen & Assoc	None	0	Ltr	Email		
49	Individual		Salvagni-Tom & Sandi	2	Ltr	Email		
50	Individual		Ed Rollins	1	Ltr	Mail		
51	Business	Energy Labs	John Standish	1	Ltr	Email		

Letter Number	Organization Type	Organization	Name	Number Signatures	Response Type	Delivery Type	Immediate Attention	Information Request
52	Business	Jefferson Local Development Corp	Bob Marks	1	Ltr	Mail		
53	Business	Holcim	Ralph Denoski	1	Ltr	Mail		
54	Business	Smith and Sons	Larry Smith	1	Form Ltr	Mail		
55	Business	Smith and Sons	Smith-Paul & Shannon	2	Form Ltr	Mail		
56	Business	Smith and Sons	Smith-Mike & Robin	2	Form Ltr	Mail		
57	Business	Smith and Sons	Smith-John & Deanna	2	Form Ltr	Mail		
58	Individual		Richard Smith	1	Ltr	Mail		
59	Business	Smith and Sons	James Pollock	1	Form Ltr	Mail		
60	Local Govt / School Dist	Whitehall Public Schools	Randy Cline	1	Ltr	Mail	Local Govt / School Dist	
61	Individual		Bob Marks	1	Ltr	Mail		
62	Business	MT Mining Assoc	Angela Janacaro	1	Ltr	Mail		
63	Individual		Jim Loomis	1	Ltr	Email		
64	Individual		Tom Harrington	1	Ltr	Mail		
65	Individual		Twila Harrington	1	Ltr	Mail		
66	Local Comm.	Whitehall CTAC	Scott Mendenhall	1	Ltr	Mail		
67	Local Govt	House Represent.	Scott Mendenhall	1	Ltr	Mail	Local Govt	
68	Individual		Darrell Scharf	1	Ltr	Mail		
69	Individual		Lawrence Fickler	1	Ltr	Mail		
70	Business	SMD	Cooper-Gary & Faith	2	Comment Form	Mail		
71	Individual		Harold Sant	1	Ltr	Mail		
72	Individual		Robert Casagrande	1	Comment Form	Mail		
73	Individual		Theresa Casagrande	1	Comment Form	Mail		
74	Ranch	Unknown	Connie Powers	1	Comment Form	Mail		
75	Individual		William Turner	1	Comment Form	Mail		
76	Fed Govt	Senate, House	Conrad Burns & Denny Rehberg	2	Ltr	Mail	Congressional	
				Total signatures 120	Total form ltr 12			

Chapter 7

Preparers and References

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Chapter 7

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7.3 GLOSSARY

Acid Generating Potential	A material's potential to generate acid and produce acid drainage. Analytical tests used to assess acid generating potential are either static or kinetic.
Acidity	The state, quality, or degree of being acid.
Acid Neutralizing Potential	The measure of a neutralizing material theoretically available to neutralize potential acid generated by ore or waste rock.
Acid Rock Drainage (ARD)	Water from pits, underground workings, waste rock, and tailings containing free sulfuric acid. The formation of acid drainage is primarily due to the weathering of iron pyrite and other sulfur-containing minerals. Acid drainage can mobilize and transport heavy metals which are often characteristic of metal deposits.
Adit	A horizontal or nearly horizontal access opening into an underground mine.
Aerobic/Anaerobic Interface	Zone in a soil or other porous media where the concentration of oxygen is detected to drop from a positive to a zero value.
Alluvium, alluvial	Unconsolidated fine to coarse material, deposited by flowing water.
Ambient	The baseline condition of a resource.
Amphibole	Any of a group of complex silicate minerals that contain calcium, sodium, magnesium, aluminum, and iron ions or a combination of them
Amphibolite	A metamorphic rock composed chiefly of amphibole with minor plagioclase and little quartz.
Analog	Something that is similar to something else.
Angle of Repose	The angle at which a loose pile of earth or rock will stand when left to itself, usually between 30° and 39°.

Aquifer	A stratum of permeable rock, sand, etc, which contains water. Water source for a well.
Archaeology	The science that investigates the history of peoples by the remains belonging to the earlier periods of their existence.
Armoring	A protective covering.
Artesian Well	A well drilled through impermeable strata to reach water capable of rising to the surface under its own pressure.
Attenuate, Attenuation	To lessen, decrease, reduce in concentration.
Backfill	Any material placed back in the pit or that would have to be removed from the pit.
Barite	A heavy yellow, white, or colorless crystalline mineral of barium sulfate that is used in paint and is the chief source of barium chemicals.
Basalt	A hard, dense, dark volcanic rock, rich in iron and magnesium.
Basin Divide	A ridge dividing two drainage basins.
Bedding Plane	A planar or nearly planar surface which visibly separates successive layers of stratified rock.
Bedrock	The solid rock that underlies gravel, soil, or other superficial material.
Belt Supergroup	A thick succession of Precambrian rocks found in Montana and nearby states and provinces.
Benchmark	A surveyor's mark made on a stationary object of previously determined position and elevation and used as a reference point in surveys.
Beneficial Use	Public use of water, including but not limited to agricultural, domestic, fish and wildlife, industrial, irrigation, mining, municipal, power, water leasing, and recreation.

Berm	A horizontal, earthen structure, often constructed on exposed slopes, which increases slope stability, redirects the flow of water or other materials, or provides a place for sloughing material to collect.
Biofouling	The undesirable accumulation of microorganisms on pump and well components.
Biotite	A dark-brown or dark-green to black mica which forms in igneous and metamorphic rocks.
Block Failure/Block Slip	A very general term that refers to a slope failure where the failing material consists of blocks of rock. The failure surface may also consist of a stepped path around blocks rather than a single plane.
Bond	A sum of money which, under contract, one party pays another party under conditions that when certain obligations are met, the money is then returned (such as after mining reclamation occurs).
Bore Hole	A circular small-diameter hole made by a drill to a desired depth.
Bornite	A copper-iron sulfide mineral; important ore of copper.
Borrow Area	An area which provides a source of earthen construction material such as sand, gravel or topsoil for use in construction or reclamation.
Breccia	Rock composed of angular fragments embedded in a fine-grained matrix.
Buffer	A substance that minimizes change in the acidity of a solution when an acid or base is added to the solution.
Calcareous	Composed of, containing, or characteristic of calcium carbonate, calcium, or limestone; chalky.
Calcite	A common crystalline form of natural calcium carbonate, $CaCO_3$, that is the basic constituent of limestone, marble, and chalk.
Calcium Carbonate	See calcite.

Candidate Species	Plant or animal species under consideration by the United States Fish and Wildlife Service listing as threatened or endangered under the Endangered Species Act.
Cap	Barren rock and/or soil covering for reclaimed areas.
Capture Point	Well for removing groundwater.
Cation Exchange Capacity	The amount of positively charged ions a soil can hold expressed in milliequivalents per 100 grams (meq/100g) of soil.
Cemented	Describes rock or soil particles held together by secondary substances like silica, calcite, or oxides.
CFR	Code of Federal Regulations. A codification of the general and permanent rules published in the Federal Register by the executive departments and agencies of the federal government.
Chalcopyrite	A copper iron sulfide ($CuFeS_2$); an important ore of copper.
Chemical Weathering	Process by which chemical reactions transform rocks or minerals into new chemical combinations stable at the earth's surface.
Chimney Effect	Convective air movement by which air is warmed and rises and is replaced by cooler air.
Circular Failure	Any slope failure where the failure surface has a circular shape.
Clean Water Act	Federal Water Pollution Control Act, as amended.
Colloidal	Pertaining to fine particles suspended in a liquid or gas.
Colluvium/Colluvial	Consisting of a mixture of soils and angular fragments of rock that have accumulated at the foot and on slopes of mountainsides under the influence of gravity.

Column Leach Test	A procedure for measuring the concentrations of constituents that can be rinsed from a material. The materials are placed in a cylindrical shaped apparatus (i.e. column) and fluid, usually distilled water, is passed through the materials. The effluent is collected and analyzed for concentration of constituents.
Compaction	An increase in the density of something; the act of crushing together.
Cone of Depression	The geometry or shape of an inverted cone on the water table or artesian pressure surface caused by the pumping of a well. The cone of depression will disappear over time when well pumping ceases.
Confidence Interval	A statistical range with a specified probability that a given parameter lies within the range.
Conglomerate	A rock consisting of rounded pebbles and gravel embedded in a finer-grained matrix.
Contrast	The effect of differences in the form, line, color, or texture of a landscape's features.
Conventional Blasting	Also called production blasting. Blast holes are drilled on a square or equilateral triangular grid. No particular design changes are made near the pit wall to improve the strength of the wall.
Corrosion	A state of deterioration in metals caused by oxidation or chemical action.
County Tax Base	Private property that is taxed by a county government.
Covellite	A dark blue sulfide of copper (CuS); an important ore of copper.
Cretaceous	The geologic period at the end of the Mesozoic Era; the span of time between approximately 136 and 65 million years ago.
Cross Section	A drawing showing a vertical section through a feature.
Crusher Reject	Crushed and screened waste rock of uniform size.

Cultural Resources	Remains of human activity, occupation, or endeavor as reflected in sites, buildings, artifacts, ruins, etc.
Daylight Level	The lowest point on the rim of an open pit.
Debris Flow	A mass of unsorted rock fragments, soil, and mud which has flowed downhill by gravity.
Decarbonization	The act of removing carbon from something.
Decay	To break down into component parts.
Devonian	The geologic period between approximately 405 million and 345 million years ago.
Dewatering	The act of removing water.
Diffusion	The process whereby particles of liquids, gases, or solids intermingle and move from a region of higher to one of lower concentration.
Digenite	A copper sulfide mineral.
Distal	Located far from a point of reference.
Down gradient	At a lower point of elevation in relation to any fixed point with regard to the direction of drainage or flow.
Drawdown	Vertical distance that a water elevation is lowered or the pressure head is reduced due to the removal of water from the same system.
Drift	A mine passage; the nearly horizontal opening driven along a vein or ore body.
Drill Log	A written record kept by drillers or geologists of materials encountered while drilling a hole.
Dynamic Systems Model	A computer tool that allows time-dependent calculations of many physical processes within a certain environment (i.e. system).
Effluent	Something that flows out, like water seeping from the pit or treated water leaving the water treatment plant.

Enargite	An iron-black mineral containing sulfur, arsenic, copper, and often silver.
Endangered species	Any species of animal or plant that is in danger of extinction throughout all or a significant portion of its range. Plant or animal species identified by the Secretary of the Interior as endangered in accordance with the 1973 Endangered Species Act.
Enrichment	Concentration of valuable constituents in an ore by mechanical or chemical weathering.
Environment	The physical, biological, and social conditions that exist within an area, including land, air, water, minerals, flora, fauna, social and economic values, and objects of historical, aesthetic, or cultural significance. The sum of all external conditions that affect an organism or community and ultimately determine its form and survival.
Environmental Assessment (EA)	A public document for which a federal or state agency is responsible that serves to: 1) Provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact; 2) Aid an agency's compliance with the National or Montana Environmental Policy Act (NEPA or MEPA) when no environmental impact statement is necessary; 3) Facilitate preparation of an environmental impact statement when one is necessary.
Environmental Impact Statement (EIS)	An analytical document prepared under the National Environmental Policy Act (NEPA) and Montana Environmental Policy Act (MEPA) that evaluates potential impacts to the environment of a Proposed Action and its possible alternatives. An EIS is developed for use by decision makers to weigh the environmental consequences of a potential decision.
Eocene	A geological epoch of the Tertiary Period; approximately 58 million to 40 million years ago.
Ephemeral (streams)	Flowing in response only to direct precipitation or snow melt.

Erosion	The group of processes whereby earth or rock material is loosened and/or dissolved and removed from any part of the earth's surface.
Ethnographic	Pertaining to the branch of anthropology that deals with the scientific description of specific human cultures.
Evaporate, Evaporation	To change into vapor.
Evapotranspiration	Loss of water by evaporation from the soil and transpiration from plants.
Expanded Ramp Pit	This refers to a particular open pit at Golden Sunlight Mines. This was the last pit stage mined before the current Stage 5B Pit. It consisted of mining an old haul road and an extension that was recovered by removing an old pit wall instability.
Facies	The aspect and characteristics of a sedimentary rock unit, usually reflecting the conditions of its origin.
Factor of Safety	A calculation defining the relationship of the strength of the resisting force of an element (C) to the demand (D) or stress on the disturbing force where F=C/D. When F is less than 1, failure can occur.
Failure Modes and Effects Analysis	An estimate of how an engineered structure might fail, the likelihood of failure, and the kind and intensity of the possible impacts.
Fault	A fracture or fracture zone along which there has been displacement of the sides relative to one another parallel to the fracture.
Fee Simple	Private ownership of real estate in which the owner has the right to control, use, and transfer the property at will.
Ferricrete	Surficial sands and gravel cemented into a hard mass by iron oxide derived from the oxidation of sulfide minerals into solutions of iron salts.
Floodplain, 100-year	That portion of a river valley, adjacent to the river channel, built of sediments and inundated with water at least once every 100 years.

Flow Path	The route by which groundwater moves.
Fluid Pressure	A force that is equal in all directions.
Fluvial	Of or relating to a stream or river.
Free Draining	Allowing water to flow off a surface.
Freeze and Thaw Cycle	Alternating episodes of freezing and thawing.
Fugitive Emissions	Those air emissions, such as road dust, which could not reasonably pass through a stack, chimney, vent, or other functionally equivalent opening. which could not reasonably pass through a stack, chimney, vent, or other functionally equivalent opening.
Galena	A gray mineral, lead sulfide (PbS), the principal ore of lead.
Gallons Per Minute (gpm)	A measurement of flow per minute. Seepage volumes are sometimes annualized to show what the steady flow in gpm would be if spread out over the entire year.
Geochemistry, Geochemical	The study of the chemical composition of, and actual or possible chemical changes in, the crust of the earth.
Geology	The science that relates to the earth, the rocks of which it is composed, and the changes that the earth has undergone or is undergoing.
Geosynthetic	Polymeric products used with soil, rock or other material as a liner or barrier to contain material or prevent erosion.
Geotechnical	Pertaining to the application of scientific methods and engineering principles to the acquisition, interpretation, and use of knowledge of materials of the Earth's crust for the solution of engineering problems. It embraces the fields of soil mechanics and rock mechanics, and many of the engineering aspects of geology, geophysics, hydrology, and related sciences.

Gneiss, Feldspathic	A metamorphic rock with prominent bands of feldspar and other minerals.
Ground Movement	General term for displacement of blocks of near-surface material by earthquakes or slow movement in response to gravity or other stresses.
Ground Support	The application of mechanical support techniques to improve stability of rock or soil slopes. These techniques include, rock bolts, rock anchors, shotcrete, wire mesh, buttresses, and retaining walls.
Groundwater	Water found beneath the land surface in the zone of saturation below the water table.
Habitat	A specific set of physical conditions that surround a single species, a group of species, or a large community. In wildlife management, the major components of habitat are considered to be food, water, cover, and living space.
Haul Road	A road used by large trucks to haul ore and overburden from an open pit mine to other locations.
Hazardous Waste	A waste or combination of wastes that, because of its quantity, concentration, or physical, chemical, or infectious characteristics, may: (i) cause or significantly contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness; or (ii) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of or otherwise managed.
Hematite	A black or blackish-red to brick-red mineral, ferric oxide (Fe_2O_3), an important ore of iron.
Hibernacula	Caves or other structures used by bats for hibernation.
Highwall	The unexcavated face of exposed waste and ore in an open pit mine (same as pit wall).
Highwall Angle	The angle from horizontal at which the unexcavated face of exposed overburden in an open pit mine is standing.

Host Rock	Unmineralized rock in which an ore deposit occurs.
Humidity Cell	A geochemical test for obtaining bulk mineral reaction rates under controlled laboratory conditions.
Hydraulic	Conveyed or moved by means of water or other fluids, or pertaining to fluid in motion, or movement or action caused by water.
Hydraulic Conductivity	The capacity of a rocks or sediments to transmit water. Governed by the size and shape of pores, the interconnection between pores, and the physical properties of the fluid.
Hydraulic Gradient	In an aquifer, the rate of change of total head per unit of distance of flow at a given point and in a given direction.
Hydrogeology/Hydrogeologic	The branch of geology that deals with the occurrence, distribution, and effect of ground water.
Hydrograph Analysis	Analysis of a chart showing stage, flow velocity, or some other characteristic of water with respect to time.
Hydrologically Connected	Water-bearing rocks and sediment and water bodies that are directly connected, such as surface water bodies and groundwater and wetlands and surface water.
Hydrologic Sink	An area that captures groundwater.
Hydrology	The science that relates to the water of the earth.
Hydrostatic Pressure	Force exerted by water at any given point in a body of water at rest.
Hydrostratigraphy	The science of the arrangement of rock strata and their interrelation to water.
Impact	Influence or effect; a modification of the environment.
Impoundment	A body of water formed by the accumulation of water in a reservoir or other storage area.

Inclinometer	An instrument used by surveyors to measure an angle of inclination or elevation.
Infiltration	The movement of water or some other fluid into the soil through pores or other openings.
Interbedded	Interlayering of different kinds of sedimentary rocks.
Intercalated	Material introduced between layers of a different kind of material, for example thin layers of shale between thick layers of sandstone.
Interfingering	Intergradation of different kinds of rocks through a vertical succession of thin interlocking or overlapping wedge-shaped layers.
Intermittent Stream	A stream that runs water in most months, but does not contain water year-round.
Intrusive Rock/Intrusion	Igneous rock formed within surrounding rock as a result of magma intrusion.
Ion Exchange	A reversible chemical reaction between an insoluble solid and a solution during which ions may be interchanged.
Iron Hydroxide	An oxide characterized by the linkage of iron with the OH ion.
Iron Oxide	Any of various oxides of iron, such as ferric oxide or ferrous oxide.
Irretrievable	Applies to losses of production, harvest, or commitment of renewable natural resources. For example, some or all of the timber production from an area is irretrievably lost during the time an area is used as a winter sports site. If the use changes, timber production can be resumed. The production lost is irretrievable, but the act is not irreversible.
Irreversible	Applies primarily to the use of nonrenewable resources, such as minerals or cultural resources, or to those factors that are renewable only over long time spans, such as soil productivity. Irreversible also includes loss of future options.

Jarosite	An ocher-yellow mineral, a hydrous sulfate of iron and potash.
Joint	A usually planar fracture surface in rock without relative displacement of the opposite sides.
Kaolinite	A clay mineral consisting of aluminum silicate ($Al_2Si_2O_5(OH)_{4)}$; main source of kaolin.
Key Cut	The low point on the pit rim where the haul road enters the pit.
Key Observation Point (KOP)	Selected points from which a BLM visual resource assessment is conducted. KOPs are typically along commonly traveled routes, critical viewpoints (e.g., communities, crossings, or observation areas) or at typical or representative viewing points.
Lacustrine	Of or relating to lakes. Found in, living, or growing in or along the edges of lakes.
Laminae	Narrow beds of rock.
Lamprophyre	Any of several intermediate igneous rocks composed of feldspar and ferromagnesium minerals that typically occur as dikes and minor intrusions.
Land Application Disposal (LAD)	The disposal of excess solution by spray irrigation over a large area where evaporation and plant uptake utilize the water. LAD is also a treatment method for some contaminants such as residual amounts of cyanide, which breaks down when exposed to oxygen and sunlight or nitrates which are used in plant growth.
Landform	A term used to describe the many types of land surfaces that exist as the result of geologic activity and weathering, e.g., plateaus, mountains, plains, and valleys.
Laramide Orogeny	A period of mountain building and deformation of the earth's crust in the western U.S., which occurred from the late Cretaceous into the early Tertiary periods.
Latite	A porphyritic volcanic rock having plagioclase and potassium feldspar present in nearly equal amounts

	of visible crystals, little or no quartz, and a finely crystalline to glassy groundmass; the extrusive equivalent of monzonite.
Leachate	A solution containing contaminants picked up as the liquid passes through soil or rock.
Lead Agency	The public agency(s) that has (have) the principal responsibility for carrying out or approving a project.
Lenticular	Lens shaped.
Lithology	The gross physical character or composition of a rock or rock formation.
Loam	Soil composed of a mixture of sand, clay, silt, and organic matter.
Locus of Shear	The geometrical plane or point along which shearing is taking place.
Loess	A buff to gray windblown deposit of fine-grained, calcareous silt or clay.
MAA	Multiple Accounts Analysis provides the means by which evaluators can select the most suitable, or advantageous, alternative from a list of alternatives by weighting the relative benefits.
Manifold	A pipe or chamber having multiple apertures for making connections.
Marcasite	A mineral with the same composition as pyrite, FeS_2, but differing in crystal structure.
Mass Balance	Calculations used to estimate the amount of mass flux into, out of, and stored within a confined volume (e.g. a pond or pit).
Mass Flux	The per unit area of mass transfer or movement.
Mass Movement/Failure	A general term that refers to failure of a large mass of material.
Mass Load, Mass Loading	The summation of mass flux into a region.

Matrix	Fine-grained material surrounding the larger particles in a sedimentary rock.
Median	The middle value in a series of numbers or data points.
Metalliferous	Containing metal.
Metal Loading	The summation of the mass flux of metals into a region.
Metamorphose	To change rock by naturally occurring heat and pressure in the earth's crust.
Metasediment	A rock resulting from the metamorphism of a sedimentary rock.
Migratory	Periodically moving from place to place.
Milliequivalent	One thousandth of a gram equivalent of a chemical.
Mineralized Zone, Mineralization	Process by which minerals are introduced into a rock, resulting in an economically valuable or potentially valuable deposit.
Mineral Reserve	A concentration or occurrence of natural, solid, inorganic, or fossilized organic material in or on the earth's crust in such form and quantity and of such grade or quality that it has reasonable prospects for economic extraction.
Minor Revision	A change in a mine permit that does not add acreage to the permit area or significantly affect the human environment.
Mitigation	Actions to avoid, minimize, reduce, eliminate, replace, or rectify the impact of a management practice or activity.
Mixing Zone	An area established in a permit where water quality standards may be exceeded to allow for initial effluent dilution.

Model, Modeling	A schematic description of a system, theory, or phenomenon that accounts for its known or inferred properties and may be used for further study of its characteristics.
Molybdenite	Molybdenum sulfide, MoS_2, the principal ore of molybdenum.
Monitoring Well	A well used to track groundwater quality or quantity.
Monzonite	An intrusive igneous rock composed chiefly of plagioclase and orthoclase, with small amounts of other minerals.
National Environmental Policy Act	(NEPA) An Act passed in 1969 declaring a national policy which will encourage productive and enjoyable harmony between humankind and the environment, to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of humanity, to enrich the understanding of the ecological systems and natural resources important to the Nation, and to establish a Council on Environmental Quality. A principal component of NEPA is the requirement to conduct EAs and EISs.
Neutralization	Reduction in acidity.
Non-homogeneous	Not uniform in structure or composition.
100-year Storm	A large storm predicted to occur about once every 100 years.
Noxious Weeds	Introduced plants that are officially recognized as undesirable by the state and county governments.
Ore	A mineral or an aggregate of minerals from which a commodity can be profitably mined or extracted.
Ore to Waste Ratio	Number of units of waste rock which must be removed to allow mining of a unit of ore.
Overbank Deposit	Mud or sand deposited beyond the banks of a stream by flooding.

Over-break	The impact of blasting damages the rocks beyond the location of the designed pit wall.
Overburden	Loose or consolidated rock material that overlies a mineral deposit and must be removed prior to mining.
Oxidation,Oxidize	The process of combining with oxygen; or the process by which electrons are removed from atoms or ions.
Oxide	A mineral compound of oxygen with one or more metallic elements; or a binary compound of oxygen with some other element or with a radical.
Oxygenated Water	Water containing dissolved oxygen gas.
Paleontology	The science that deals with the life of past geological ages through the study of the fossil remains of organisms.
Paleozoic	Span of time from end of Precambrian to beginning of Mesozoic Era, ranging from about 570 million to 250 million years ago.
Particulate(s)	Minute, separate particles, such as dust or other air pollutants.
Passivation	A patented process using potassium permanganate sprayed on pit walls and waste rock to prevent pyrite oxidation.
Patented	A mining claim owned by legal title.
Partial Pit Backfill	Partial filling of the pit but not attempting to mound the fractured rock to the original configuration of the mountain.
Percolation Pond	An unlined pond that allows water to seep through the bottom.
Perennial Stream	A stream that flows at all times of the year.
Permeability	The property or capacity of a porous rock, sediment, or soil for transmitting a fluid.
Petrographic	Of the description and classification of rocks.

pH	The measure of acidity or alkalinity of a solution.
Physical (Mechanical) Weathering	Breakdown of rock into smaller fragments by physical means like freezing and thawing, as opposed to chemical processes.
Pit Backfilling	Process of placing waste rock back into the pit from which it came.
Pit Highwall	Steep rock surfaces bordering a pit after removal of ore and waste.
Plaintiff	The party that brings a law suit against another party.
Plan View	Diagram showing features as seen from above; map view.
Pore Pressure	The hydrostatic pressure of the water in the pore space of a soil.
Pore Water	Water found in the pores of rock.
Porosity	The ratio of the volume of all the pores in a material to the volume of the whole.
Porphyry	Igneous rock containing relatively large conspicuous crystals, especially feldspar, in a fine-grained matrix.
Portal	Horizontal entrance to an underground mine.
Potentiometric Surface	The surface to which water in an aquifer would rise by hydrostatic pressure.
Precambrian	About 90 percent of geologic time; all time which precedes Paleozoic.
Precipitate	To cause a solid substance to be separated from a solution.
Preferential Flowpath	The most likely direction of groundwater flow.
Pre-split Blasting	A smooth blasting method in which cracks for the final contour are created by blasting prior to the drilling of the rest of the holes for the blast pattern.

Principal Deformation Zone	The principal axis of distorted rocks along a fault or other structural feature.
Proterozoic	The period of Earth's history that began 2.5 billion years ago and ended 543 million years ago; a subdivision of Precambrian time.
Pumpback System	A series of wells designed to capture groundwater and return it to some specific location.
Pyrite	A common brass-colored sulfide mineral, FeS_2, also known as “fool's gold.”
Quaternary	The second period of the Cenozoic era, following the Tertiary; began 2 to 3 million years ago and extends to the present.
Raise	A mine opening driven vertically from a lower to higher level.
Ramp	A sloping mine excavation.
Raptor	Bird of prey.
Raveling	Any small-scale localized failure of the highwall.
Receptor	Someone or something that receives a stimulus, such as noise.
Reclamation	To return a disturbed area to an approved post-mining land use.
Recontouring, Regrading	Reshaping irregular piles or dumps of rock or earth to a desired shape or form.
Record of Decision (ROD)	A document separate from but associated with an Environmental Impact Statement that publicly and officially discloses the responsible official's decision on the proposed action.
Redox Potential	The tendency for transfer of electrons from one compound to another. The donor is oxidized, the acceptor reduced.
Region	A large tract of land generally recognized as having similar character and physiographic types.

Right-of-Way	Strip of land over which a powerline, access road, or maintenance road has a legal right to pass.
Riparian	A type of ecological community that occurs adjacent to streams and rivers and is directly influenced by water. It is characterized by certain types of vegetation, soils, hydrology, and fauna, and requires free or unbound water or conditions more moist than normally found in the area.
Riprap	A layer of large, broken rock placed together irregularly to prevent erosion of embankments, causeways, or other surfaces.
Risk	The possibility of suffering harm or loss; danger.
Rock Bolt	Steel bolt with one flanged end and one expanding end; placed in a pre-drilled hole to control rock movement.
Runoff	Precipitation or snow melt that is not retained on the site where it falls, not absorbed by the soil; natural drainage away from an area.
Safety Bench	Wide bench in an open pit mine designed to catch falling or sliding rocks and debris and provide protection to workers and features below.
Safety Berm	Rock or earthen barrier along a bench or road, designed to keep vehicles and workers away from a dangerous edge.
Salvaged	Recovered or saved, such as soil that is picked up for future use in reclamation.
Saturated, Inundated	Soaked, filled, or loaded to capacity.
Scaling	Development of hard, brittle, cement like deposits, usually due to the precipitation of calcium and magnesium carbonates.
Scaling	The plucking down of loose rocks adhering to the solid face after a shot or round of shots has been fired.

School Trust Land	State land set aside specifically as a source of income to public schools in Montana and managed by the Montana Department of Natural Resources and Conservation.
Scoping	A term used to identify the process for determining the scope of issues related to a Proposed Action and for identifying significant issues to be addressed in an environmental impact statement.
Sedimentary	A type of rock resulting from consolidation of loose sediment that has accumulated in layers.
Seismicity	The likelihood of an area being subjected to earthquakes; the phenomenon of earth movements.
Sericite	A fine-grained potassium mica occurring in silky scales having a fibrous structure; a common alteration product of other silicate minerals.
Shear Zone	A body of rock broken by numerous, closely spaced, nearly parallel fractures.
Silicate Dissolution	The act of dissolving minerals composed of silica (e.g. quartz).
Slip Block	A body of rock or land which has slid away from its original position along a low-angle surface; usually bounded by near-vertical breaks.
Slope Acre	An acre of land in plan view adjusted for degree of slope.
Slough	A backwater or isolated bend of a stream.
Slough	Any large-scale mass failure of the highwall.
Sludge	Semisolid material precipitated in a water treatment plant.
Slurry	A thin mixture of water and finely ground ore.
Smectite	A group of clay minerals, often greenish.

Soil Development	The development of an unconsolidated layer of weathered rock which lies upon bedrock and is a medium for plant growth.
Sorption, Sorbing	The process in which one substance takes up or holds another by either absorption or adsorption.
Species	A group of individuals of common ancestry that closely resemble each other structurally and physiologically and in nature interbreed producing fertile offspring.
Sphalerite	The primary ore of zinc, occurring in usually yellow-brown or brownish-black crystals or cleavage masses, essentially ZnS with some cadmium, iron, and manganese.
Stakeholder	One who has a share or an interest in something.
Steady State	A stable condition that does not change over time or in which change in one direction is continually balanced by change in another.
Stipulation	A condition attached to a mine's operating permit.
Stockpiled	Set aside for future use
Stope	Any excavation underground to remove the ore, other than the development work. The outlines of a stope are determined either by the limits of the ore body or by raises.
Stratigraphy, Stratigraphic	Form, arrangement, geographic distribution, chronologic succession, classification, and relationships of rock strata.
Subsidence	Settling caused by the collapse of an underground mine.
Sulfate	A chemical compound containing SO_4.
Sulfide	A mineral composed of sulfur combined with a metal or semi-metal, for example pyrite and bornite.
Sump	The bottom of a shaft or any other place in a mine that is used as a collecting point for drainage water.

Supplemental EIS	A supplemental analytical document prepared under the National Environmental Policy Act (NEPA) and Montana Environmental Policy Act (MEPA) that portrays potential impacts to the environment of a Proposed Action and its possible alternatives. A SEIS is developed for use by decision makers to weigh the environmental consequences of a potential decision.
Surficial Geology	Of or relating to the geology of the surface of the earth.
Survey Prism	Device used to monitor movement of slip blocks or other features.
Syncline	A fold in rocks in which the rock layers dip inward from both sides toward the axis.
Tailings	The non-economic constituents of processed ore material that remain after the valuable minerals have been removed from raw materials by milling.
Talus	Heaps of coarse debris at the foot of cliffs and steep slopes resulting from weathering processes and gravity transport.
Tectonic Zone	Large-scale structural feature of the upper part of the earth's crust characterized by present or past seismic movements.
Telluride	A binary compound of tellurium usually with an element or radical, such as gold or silver. Metal tellurides are sometimes regarded as alloys.
Tertiary	A geologic period; the span of time between about 65 and 3 to 2 million years ago.
Texture	The composition of soil in terms of the relative proportions of sand, silt, and clay.
Threatened species	Any species likely to become endangered within the foreseeable future throughout all or a significant part of its range.
Topographically Controlled	Constrained by the shape of the land surface.

Tributary	A stream flowing into a larger stream or other body of water.
Uncertainty	The estimated amount or percentage by which an observed or calculated value may differ from the true value.
Unconformably, Disconformably	Characterized by a substantial break or gap in the geologic record.
Unnecessary or Undue Degradation	Under BLM regulations: conditions, activities, or practices that: (1) Fail to comply with one or more of the following: the performance standards in Sec. 3809.420, the terms and conditions of an approved plan of operations, operations described in a complete notice, and other Federal and state laws related to environmental protection and protection of cultural resources; (2) Are not ``reasonably incident'' to prospecting, mining, or processing operations as defined in Sec. 3715. 0-5 of this chapter; or (3) Fail to attain a stated level of protection or reclamation required by specific laws in areas such as the California Desert Conservation Area, Wild and Scenic Rivers, BLM-administered portions of the National Wilderness System, and BLM-administered National Monuments and National Conservation Areas.
Unpatented	A mining claim controlled by staking and assessment work, not by full legal ownership.
Unsaturated	Not soaked, filled, or loaded to capacity
Up gradient	At a higher point of elevation in relation to any fixed point with regard to the direction of drainage or flow.
Vat Cyanide Leach Process	Recovery of gold and other metals by soaking a concentrate milled from ore in a cyanide solution contained in a cylindrical vertical vat.
Visual Contrast	Noticeable visual difference between the natural landscape and adjacent reclaimed areas.
Visual Resource Inventory	A BLM system of determining visual values in an area by inventorying existing scenic quality, sensitivity level, and distance zones. Inventory classes of one through four are assigned.

Visual Resource Management	A BLM system of analyzing the potential visual impacts of a proposed project or activity by assessing the visual contrasts that would be created between a project and the existing landscape. The major features of form, line, color, and texture are evaluated.
Volcanic	Activities, structures, or rock types produced by a volcano.
Waste Rock	Rock that is removed to access precious metal-bearing ore, but does not contain enough mineral to be mined and processed at a profit.
Waste Rock Dump	Storage area for waste rock.
Water Balance	An account of all the inflows and outflows for a given basin with no net change in storage. Factors include precipitation, evapotranspiration, streamflow, water use, and any transfers of groundwater out of the basin.
Water Holding Capacity	The amount of water stored in a soil after the large (macro) pores have drained. Dependent upon soil texture and organic matter content.
Water Quality Standards	Limits on water pollutants designed to protect human health, aquatic life, and beneficial uses, as listed in DEQ's Circular WQB-7.
Watershed	The entire land area that contributes water to a particular drainage system or stream.
Water Table	The level below which the ground is completely saturated with water.
Weathered Waste Rock	Waste material which has been subjected to chemical and mechanical weathering after being moved to dumps.
Wedge Failure	Any failure where the planes which failure is occurring along have a wedge shaped geometry.
Well Completion Details	A record of the depth and manner in which a water or monitoring well has been constructed and equipped.

Wetlands	Areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. BLM Manual 1737, Riparian- Wetland Area Management, includes marshes, shallow swamps, lakeshores, bogs, muskegs, wet meadows, estuaries, and riparian areas as wetlands.
Working Surface	An area leveled off to provide a place to work, as the bottom of an open pit.

7.4 ACRONYMS AND ABBREVIATIONS

AGP	Acid Generating Potential
ARD	Acid Rock Drainage
BLM	U.S. Bureau of Land Management
CEC	Cation Exchange Capacity
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cm/sec	centimeter per second
cy	cubic yard
DEQ	Montana Department of Environmental Quality
DNRC	Montana Department of Natural Resources and Conservation
DSL	Montana Department of State Lands
DSM	Dynamic Systems Model
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
g	gram
gpm	gallons per minute
GPS	Global Positioning System
GSM	Golden Sunlight Mine
HDPE	High-density Polyethylene
hp	horsepower
ISB	Intermountain Seismic Belt
KOP	Key Observation Point
LAD	Land Application Disposal
LSI	Langelier Saturation Index
LTA	Lost Time Accident
MAA	Multiple Accounts Analysis
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
MEPA	Montana Environmental Policy Act
meq	millequivalent
mg/l	milligram per liter
MMRA	Montana Metal Mine Reclamation Act
MSHA	Mine Safety and Health Administration
MTARNG	Montana Army National Guard
NEPA	National Environmental Policy Act
NNP	Net Neutralizing Potential
NOI	Notice of Intent
PDZ	Principal Deformation Zone
ppm	parts per million
PVC	Polyvinyl Chloride
RMP	Resource Management Plan
ROD	Record of Decision
SEIS	Supplemental Environmental Impact Statement

SHPO	Montana State Historic Preservation Office
T/Q	Tertiary/Quaternary
Tba	Tertiary Bozeman Group alluvial facies
Tbf	Tertiary Bozeman Group fluvial facies
Tdf	Tertiary debris flow
TDS	Total Dissolved Solids
Tg	Tertiary alluvial fan gravels
Tls	Tertiary land slide
Ts	Tertiary lacustrine sands
TWG	Technical Working Group
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VRI	Visual Resource Inventory
VRM	Visual Resource Management
WTP	Water Treatment Plant

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